Ontario

Ministry of
Transportation

Research and
Development
Branch

SP-022

flexible
pavement
condition
rating

Technical Report Documentation Page

Flexible Pavement Condition Rating – Guidelines for Municipalities

Authors:	G.J. Chong and W.A. Phang, Pavements & Roadway Office, Research & Development Branch G.A. Wrong, Design Evaluation and Pavement Section, Highway Design Office
Number:	SP-022 ISBN 0-7729-5427-5, ISSN 0226-9414
Date of Publication:	August 1989
Ministry Contact:	Pavements and Roadways Office, Research & Development Branch (416) 235-4742
Abstract:	Most highway authorities use highway pavement surface condition ratings to judge the pavement's ability to continue providing required service to the public. Municipalities in Ontario have the same duty to monitor and maintain the roads in their respective communities. Riding quality and distress manifestations are the bases of the pavement condition rating scheme used in Ontario by the Ministry of Transportation. However, a scheme is required that specifically addresses the unique conditions and needs of municipal roads. This document was prepared to meet this pavement management need and to present a pavement surface condition rating scheme for municipal roads and streets, also using riding quality and distress manifestations as its bases.
Comments:	
Key words:	Condition rating, pavement management, municipal roads, pavement distress, maintenance
Distribution:	Regional Geotechnical Offices, Municipal Roadway Offices
Copyright Status:	Crown copyright © 1989 Ministry of Transportation

Ontario

Ministry of
Transportation

Research and
Development
Branch

SP-022

flexible pavement condition rating

guidelines for municipalities

G.J. Chong
Research Engineer

W.A. Phang
Principal Research Engineer

Pavements and Roadway Office
Research and Development Branch

G.A. Wrong
Head, Design Evaluation and Pavement Section
Highway Design Office

Published by
The Research and Development Branch
Ministry of Transportation of Ontario
Hon. William Wrye, Minister
D.G. Hobbs, Deputy Minister

Published without prejudice as to the application of the findings.
Crown copyright reserved; however, this document may be reproduced for non-commercial purposes with attribution to the Ministry.

For additional copies, contact:
The Editor, Technical Publications
Room 320, Central Building
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8

Telephone:	(416) 235-3480
Fax:	(416) 235-4872
CNCP Dialcom Electronic Mail:	23:MIN006

August 1989

Table of Contents

1/ Introduction **1**

2/ Pavement Surface Condition Rating Scheme **2**

3/ Procedure for Pavement Evaluation **5**

4/ Riding Quality (Riding Condition Rating) **6**

5/ Distress Manifestations **12**

- 5.1/ Surface Defects 15
  - Ravelling 16
  - Flushing 18
  - Potholes 20
  - Pavement Edge Breaks 22
  - Manholes and Catchbasins 24
- 5.2/ Surface Deformation 27
  - Rippling and Shoving 28
  - Wheel Track Rutting 32
  - Distortion 34
  - Utility Trenches 40
- 5.3/ Cracking 45
  - Longitudinal Cracking 46
  - Transverse Cracking 48
  - Pavement Edge Cracking 52
  - Map Cracking 56
  - Alligator Cracking 60

6/ Paved Shoulder Distress Manifestations **63**

- Pavement Edge, Paved Shoulder (or Curb) Separation 64
- Paved Shoulder Cracking 66
- Paved Shoulder Breakup and Potholes 67
- Paved Shoulder Distortion 69

7/ Maintenance Treatment Alternatives **71**

- Treatment Alternatives 72
- Manual Patching 73
- Machine Patching 74
- Cold Milling or Hot Planing with Manual Patching 75
- Cold Milling or Hot Planing with Machine Patching 76
- Manual Spray Patching 79
- Manual Chip Seal 80
- Machine Chip Seal 82
- Fog Seal 83
- Surface Treatment 84
- Manual Burn and Seal 86
- Crack Rout and Seal 87

References **89**

Appendix A

A Guide for Completing the “Flexible Pavement Condition Evaluation Form” ... 91

Tables

1/ Riding Condition Rating Guide 6

A-1/ A Guide for the Estimation of Pavement Condition Rating and Suggested Maintenance or Rehabilitation for Municipal Roads and Streets 95

Figures

1/ Distress Manifestations and Maintenance Treatment Alternatives 4

2/ Intermittent Occurrence of Potholes 12

3/ Intermittent Occurrence of Potholes 12

4/ Frequent Occurrence of Potholes 13

5/ Extensive Occurrence of Potholes 13

A-1/ Flexible Pavement Condition Evaluation Form (Municipalities) 94

1/ Introduction

Rating of highway pavement surface condition is used in one form or another by most highway authorities as a measure of the ability of the pavement to continue to provide required service to the public. The most important applications for condition ratings are their use in determining deficiencies, inadequacies, remedial measures, fiscal needs, and in programming. The pavement condition rating scheme used in Ontario by the Ministry of Transportation is based on two interrelated measures – riding quality and distress manifestations [1,2,3].

Municipalities in Ontario must manage a network of roads and streets to ensure adequate capacity and safety for the public [4]. Therefore, municipalities have the same requirement of the highway agencies in evaluating pavement surface condition of their roads and streets. But to date, there is no single scheme which is designed and developed specifically to address the unique conditions, needs, and traffic characteristics faced by the Ontario municipalities.

This document is prepared to meet this pavement management need and to present a pavement surface condition rating scheme for municipal roads and streets. The scheme is based on the same interrelated measures used by the highway system, namely, the riding quality and distress manifestations.

This document is the co-operative result between the Ministry's Research and Development Branch and the participating municipalities. Participation takes the form of simple inventory data of pavement surface types and locations within the municipal boundary, and valuable contributions in the form of suggestions, comments, and recommendations. The participating municipalities are:

City of Belleville
Township of Ernestown
Town of Ingersoll
Town of Picton
Township of Delhi
Town of Gananoque
City of Owen Sound
City of Woodstock

Valuable contributions toward the preparation of this document were also received from the Ministry's Design Evaluation and Pavement Section of the Highway Design Office, and the Regional Geotechnical Offices of the five regions.

2/ Pavement Surface Condition Rating Scheme

The rating scheme devised for use by municipalities in Ontario consists of a rater evaluating two different physical parameters:

- the riding quality of the pavement surface which is the indicator for pavement functional condition, and
- the extent and severity of pavement surface distress manifestations which is the indicator of pavement structural condition.

The two physical parameters are interrelated by reason that some distress manifestations result in surface distortion and unevenness which then cause a reduction in riding quality. A prime example is transverse crack lipping or cupping resulting in a rough ride for the road users. However, rougher pavements, in turn, cause vehicles to produce higher dynamic wheel loads, thus increasing stresses, strains, and deflections and hastening pavement deterioration. Not all distress manifestations are accompanied by distortion or unevenness. The type of distress and the extent and severity of occurrence are all very useful indicators of structural inadequacy, materials deficiency and probable rate of subsequent deterioration.

Riding quality is a perceived measure and it is quite practical for the experienced rater to evaluate ride quality. The ability of the rater to provide a subjective measure of ride condition using the guidelines will improve with rater experience. Mechanical measurements using such roughness devices as the Mays Meter, PURD, or the ARAN may be made in lieu of subjective riding condition rating. However, the numerical value measured by these mechanical devices must be equated to the same subjectively derived riding condition rating scale.

Distress manifestations of pavement surface may be grouped under three main headings:

- surface defects
- distortion or permanent deformation
- cracking

The different distress manifestations have been assigned names, which are listed in Figure 1. Each type of distress is given a description of its physical appearance, and an array of possible causes. Each type of distress is evaluated in terms of the extent or density of occurrence and in terms of its severity. Uniform word descriptions are given to correspond with each category of density or severity.

Pavement condition rating based on the two physical parameters should reflect the average condition of the pavement section rated. This requires that roads and streets be divided into sections exhibiting relatively uniform performance. In general, sections should start and end at major intersections. A preliminary evaluation of riding quality may enable the rater to identify sections with substantially different qualities and the project may be subdivided by such changes. However, it is suggested that in rural situations the subsection should not be less than 1.6 kilometres, and in the case of urban streets the distance between two intersections (if uniform in performance appearance). Intersections should be included as part of the evaluation section for both rural and urban situations.

Pavement condition ratings are to be carried out in the late spring and summer months to allow for the effects of frost heaving to dissipate, and to allow the pavement to stabilize.

Pavement shoulder and curb-and-gutter distresses, although not directly affecting the pavement surface condition, do contribute to the overall pavement performance. Therefore, evaluation should be made to round out the total performance picture. For practical purpose, only paved or bituminous stabilized shoulders are considered and the distresses are grouped under the following headings:

- pavement edge and paved shoulder (or curb) separation
- cracking
- breakup and potholes
- distortion

Maintenance treatments carried out on the pavement surface do contribute directly to the overall pavement performance, especially the pavement functional condition because treatments can and do directly affect the riding quality of the pavement surface. Therefore, reporting on the type and extent of maintenance treatment carried out on the pavement is desirable and necessary.

Although the purpose of the rating scheme is to describe distress manifestations of the pavement, possible matching remedial measures are also suggested under each distress manifestation for maintenance action. However, it should be understood that the possible remedial measures suggested for a deficiency might not necessarily be the most effective maintenance alternatives, nor will these measures necessarily effectively correct the cause or causes of the distress. That is, the listed remedial measures may only be expedient maintenance treatments to slow the deterioration.

Pavement conditions ratings are needed at regular time intervals so that management can be aware of changing conditions and can plan maintenance and rehabilitation with confidence. The completeness and uniformity of condition reports should lead to increased confidence in planning. The preferred cycle is one year, but if this is not feasible or economical, the maximum interval is three years.

This pavement surface rating scheme is not a duplication of the MTO's Municipal Road Needs Study [4]. The road data requirements for the Road Needs Study, though similar, are not the same, and they cannot be converted from the Needs Study requirement to the requirements of pavement management. The parameters for evaluation are different between the two. For example, the method of rating structural adequacy for the Needs Study is to consider the relative area of occurrence of the surface distress of alligator cracking and wheel track cracking type, as well as maintenance demand.

However, this pavement surface rating scheme appears to be convertible to fulfill Road Needs Study data requirements because the surface condition rating of Road Needs is quite similar in concept to the measurement of riding quality of the rating scheme. Similarly the assessment of structural adequacy required for the Road Needs can be derived readily from the distress manifestation evaluation of this pavement surface rating scheme.

Therefore, it is reasonable to assume that pavement condition ratings data is not only capable of meeting the requirements of pavement management, but also capable of being transposed to meet the requirements of the Road Needs Study.

Figure 1/ Distress Manifestations and Maintenance Treatment Alternatives

Pavement Distress Manifestation	Evaluation		
	Severity	Density	Other Characteristics
Pavement Surface Defects			
• Ravelling			
• Flushing			
• Potholes			
• Pavement Edge Breaks			
• Manholes and Catchbasins			
Pavement Surface Deformation			
• Rippling and Shoving			
• Wheel Track Rutting			
• Distortion			
• Utility Trenches			
Pavement Cracking			
• Longitudinal			
• Transverse			
• Pavement Edge			
• Map			
• Alligator			
Paved Shoulder Distress Manifestation			
• Pavement Edge and Paved Shoulder (or Curb) Separation			
• Cracking			
• Breakup and Potholes			
• Distortion			
Maintenance Treatment Alternatives			
• Manual Patching			
• Machine Patching			
• Cold or Hot Milling with Manual Patching			
• Cold or Hot Milling with Machine Patching			
• Manual Spray Patching			
• Manual Chip Seal			
• Machine Chip Seal			
• Fog Seal			
• Surface Treatment			
• Manual Burn and Seal			
• Crack Rout and Seal			

3/ Procedure for Pavement Evaluation

Step 1 To carry out the pavement condition evaluation, drive slowly over the road or street to visually inspect the overall surface condition of the pavement for uniformity in appearance. If distinctive difference is observed, then the pavement should be subdivided into two (or more) appropriate sections for evaluation.

However, each evaluation section should have a minimum length of 1.6 kilometres for rural road situations, and the distance between two intersections for urban street situations regardless of length. This minimum length requirement is strictly for economic reasons.

Step 2 After establishing the evaluation section, assessment of the pavement functional condition is made by obtaining the Riding Condition Rating (RCR). Riding Condition Rating is obtained by averaging the ride quality of both directions of the pavement. Drive over the pavement at the posted speed; that is, if speed limit posted is 50 km/h then evaluation must be made at 50 km/h. However, if it's not possible to maintain the posted speed limit safely, the pavement should be rated at a safe speed and that speed should be noted. For urban situation where the evaluation section covers more than one block with "STOP", traffic regulations must be observed, but the Riding Condition Rating should be obtained by averaging the whole evaluation section.

Step 3 After assessing the Riding Condition Rating, assessment of the pavement structural condition is made by driving over the pavement slowly to assess distress manifestations (maximum speed not to exceed 50 km/h for rural roads, or 30 km/h for urban street). Two or three stops per section should be made to examine distress type and severity, particularly surface conditions and surface deformations.

Step 4 Complete the "Flexible Pavement Condition Rating Form" by checking off the "Riding Condition Rating" and all observed distress manifestations, shoulder distress manifestations, and maintenance treatments at their appropriate places (Figure A-1, Appendix A).

Step 5 Pavement Condition Rating (PCR) is assigned according to the guide for the estimation of pavement condition rating for municipal roads and streets (Table A-1) given in Appendix A.

4/ Riding Quality (Riding Condition Rating)

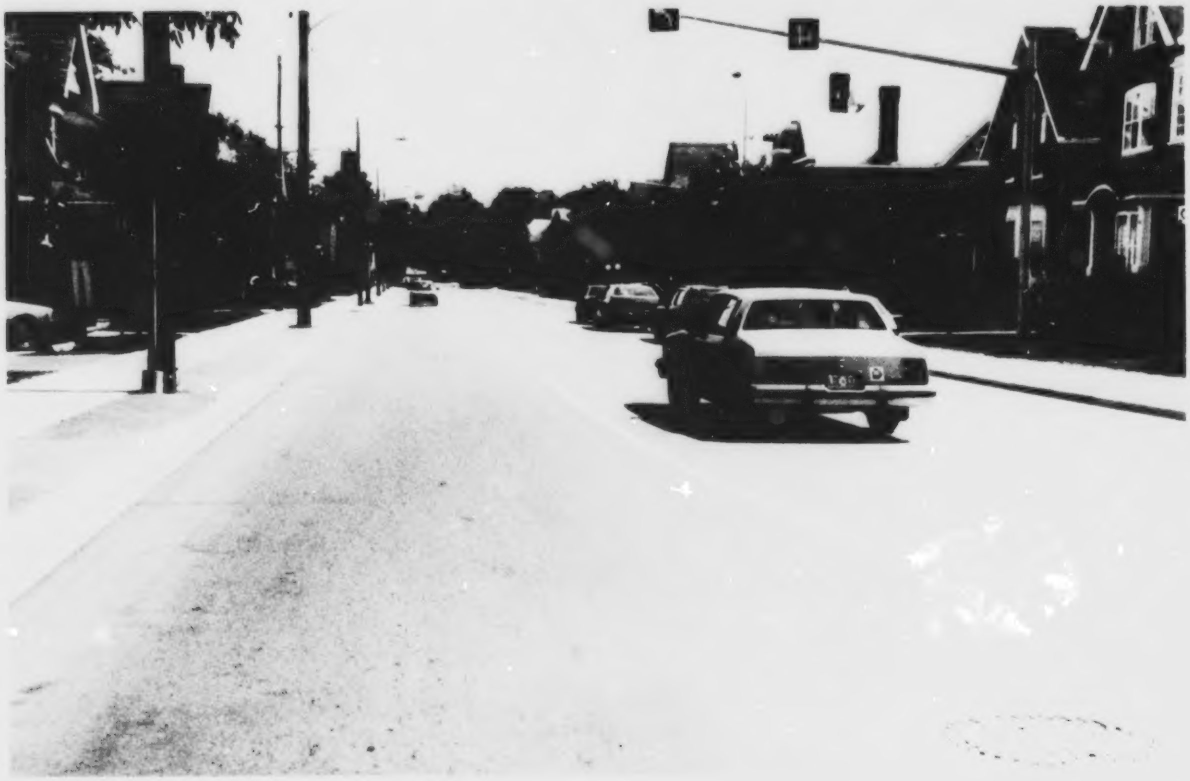
The riding quality of a pavement is the degree of surface smoothness which the pavement section in question provides to the travelling public. The rater should drive over the pavement section at the posted speed and having done so, classify the pavement's riding condition according to the descriptions given in Table 1.

The type of passenger vehicle used for performing this Riding Condition Rating has no significant influence on the rater. This finding was reported in an experimental study conducted by MTO in 1968 when over 100 individual raters and different types and sizes of automobiles were used [5]. Therefore, it is not necessary to specify any particular vehicle for assessment of the Riding Condition Rating of the pavement surface. If, however, a municipality wishes to establish uniformity of vehicles used for the rating, a half-ton patrol truck would serve well. This type of vehicle is probably part of every municipal fleet.

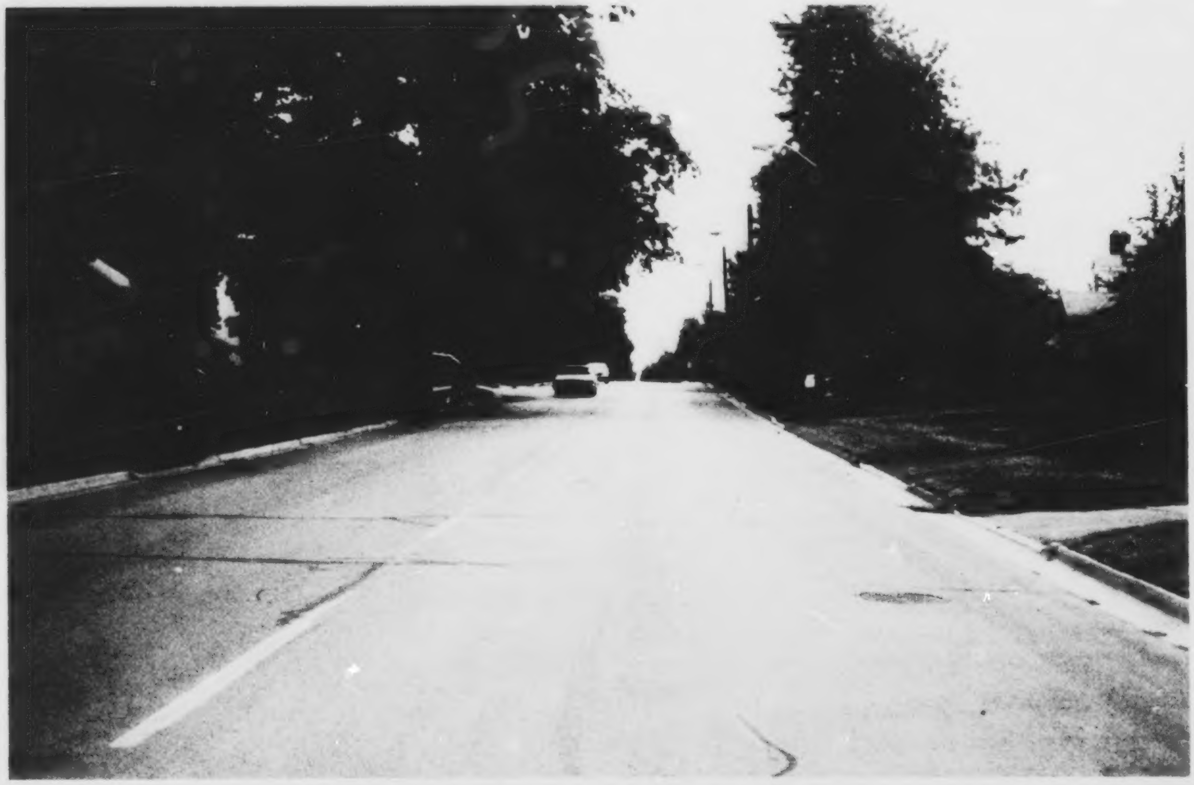
It is important that the rater should try not to be influenced by the appearance of the pavement surface when rating riding condition – only the riding condition the pavement provides to the rater should be considered relevant. It is also important that the rater should try not to be influenced by the pavement's class when rating riding condition. The class of roads and streets being rated should be considered irrelevant: a connecting link and a residential street should be considered as equal when assessing riding condition.

Table 1/ Riding Condition Rating Guide

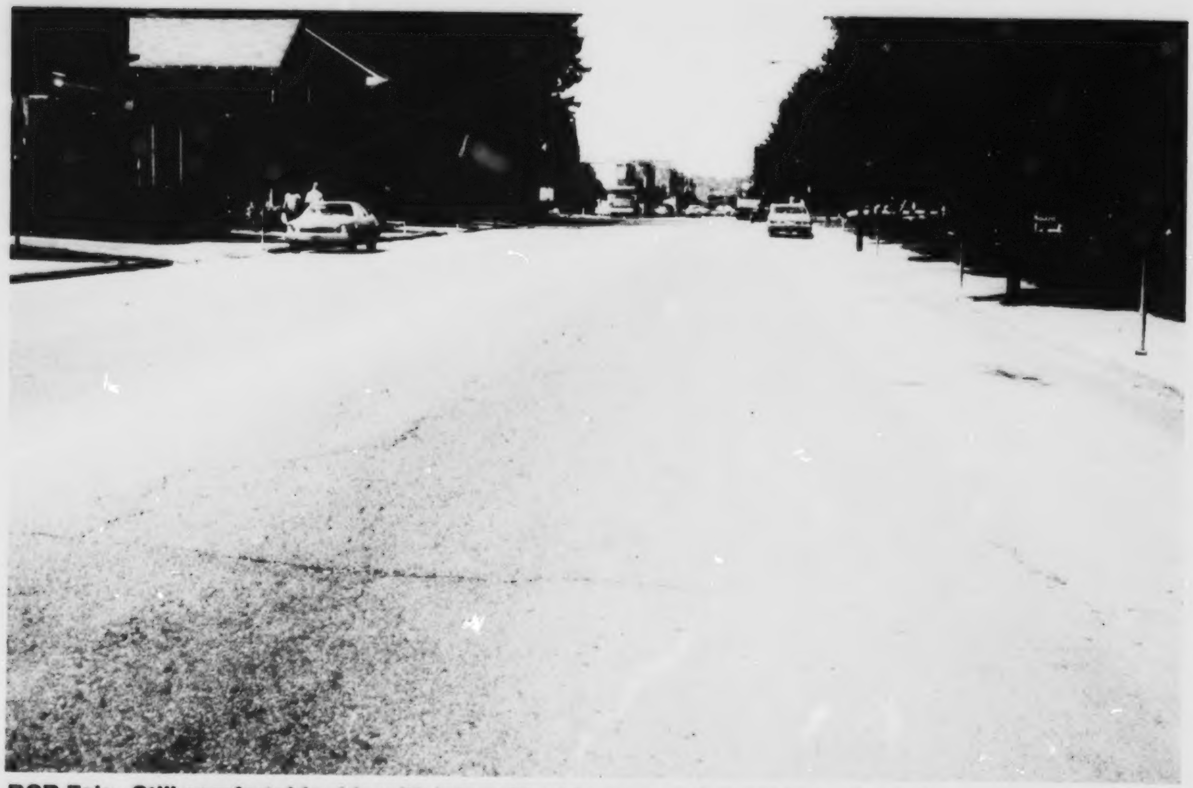
RCR	Uniform Description of Riding Condition at Posted Speed (RCR)	Guidelines
8-10	Excellent	Very smooth ride.
6-8	Good	Smooth ride with just a few bumps or depressions.
4-6	Fair	Still comfortable ride with intermittent bumps or depressions.
2-4	Poor	Uncomfortable ride with frequent bumps or depressions.
0-2	Very poor	Uncomfortable ride with constant bumps or depressions resulting in rattle and shake of rating vehicle. Cannot maintain posted speed and must steer constantly to avoid bumps or depressions.



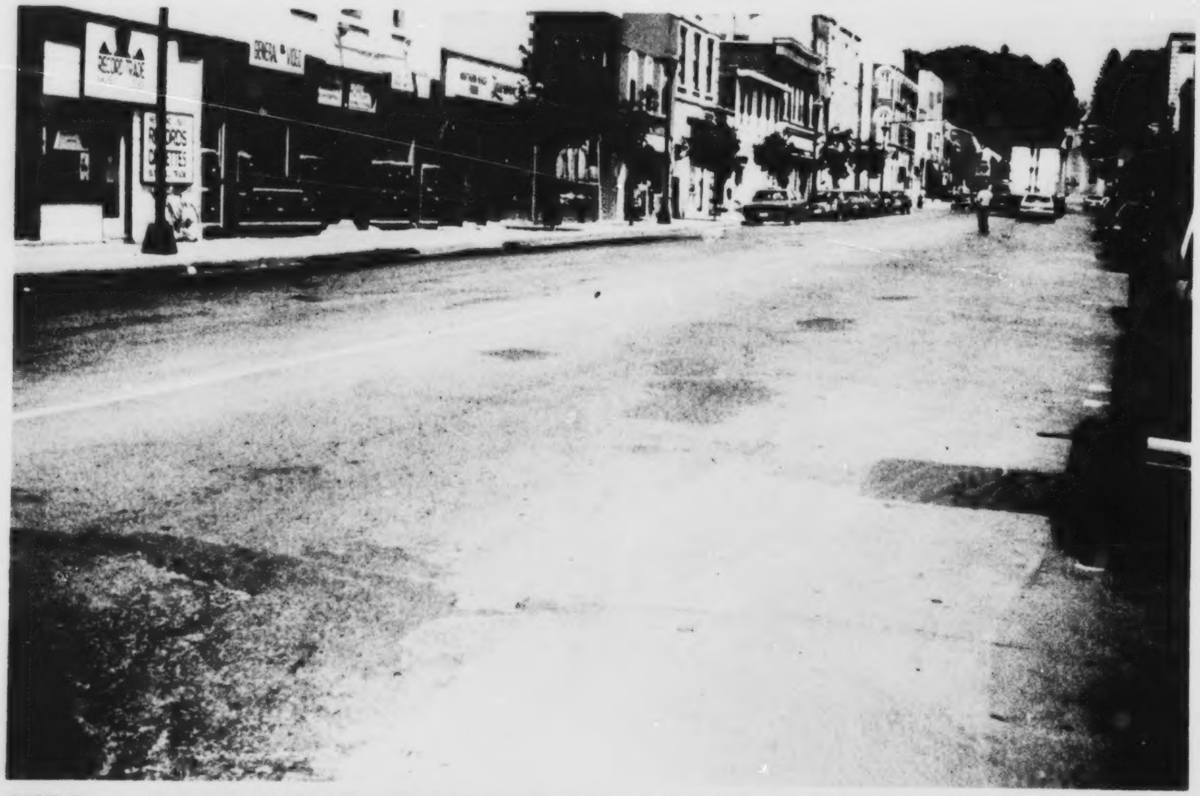
RCR Excellent: Very smooth ride. (Urban)



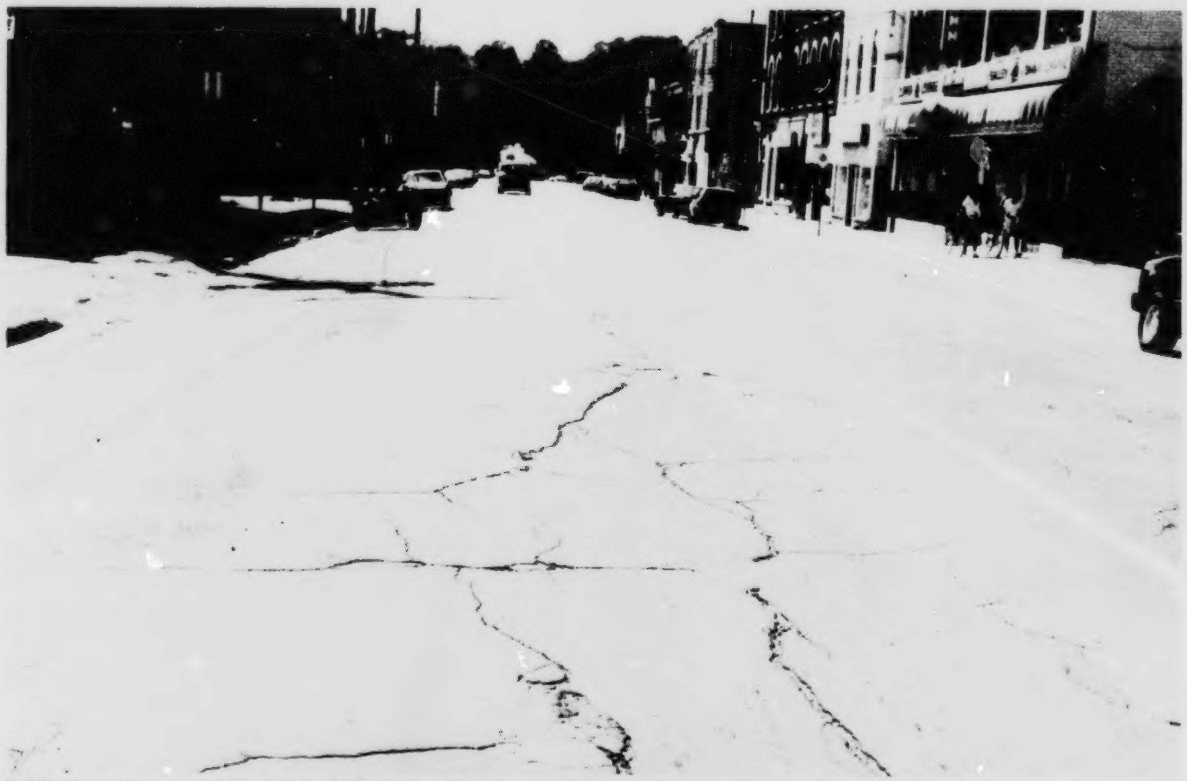
RCR Good: Smooth ride with just a few bumps or depressions. (Urban)



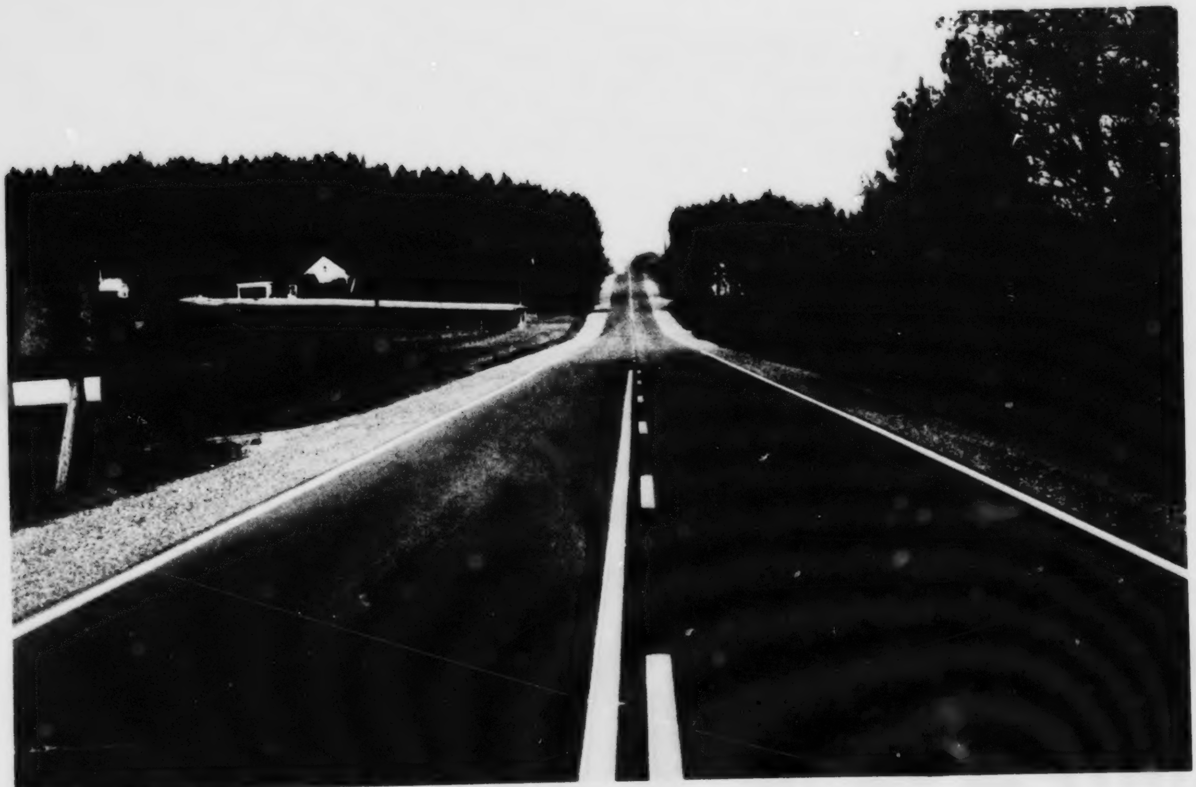
RCR Fair: Still comfortable ride with intermittent bumps or depressions. (Urban)


RECORD TRADE
GENERAL
RECORDS
CASSETTES

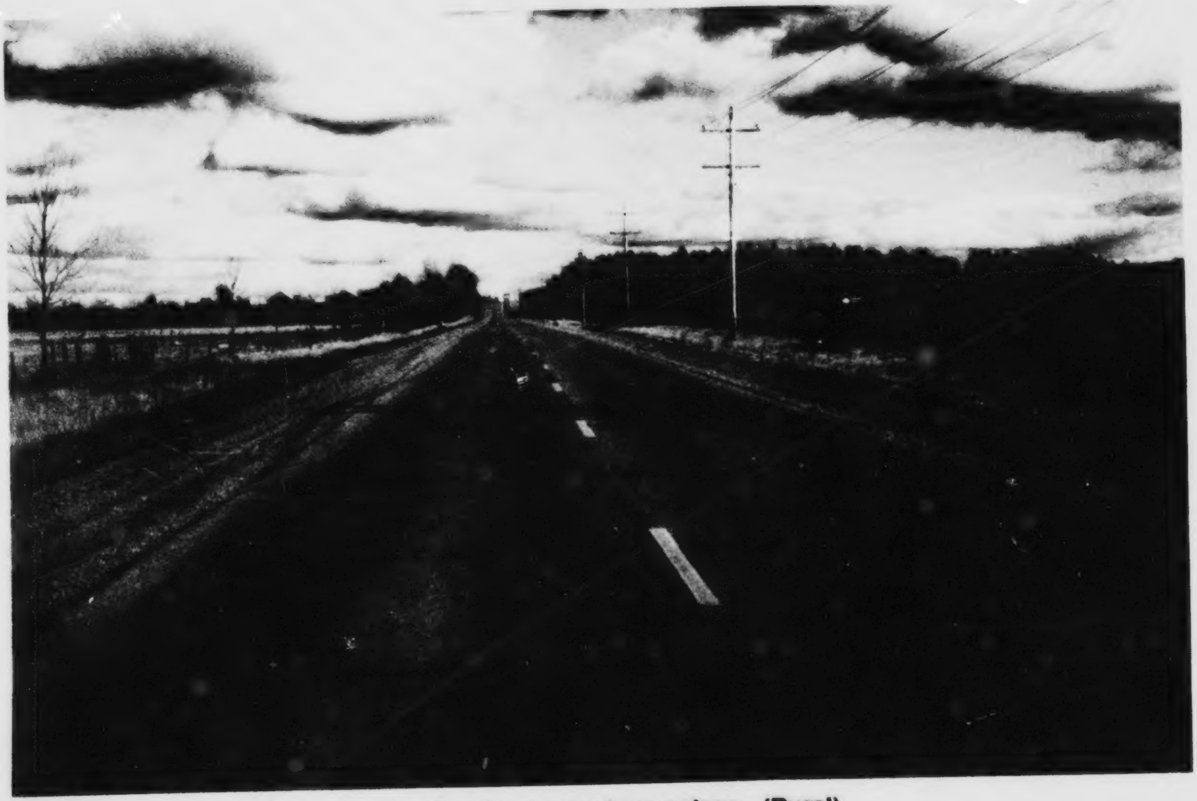
RCR Poor: Uncomfortable ride with frequent bumps or depressions. (Urban)



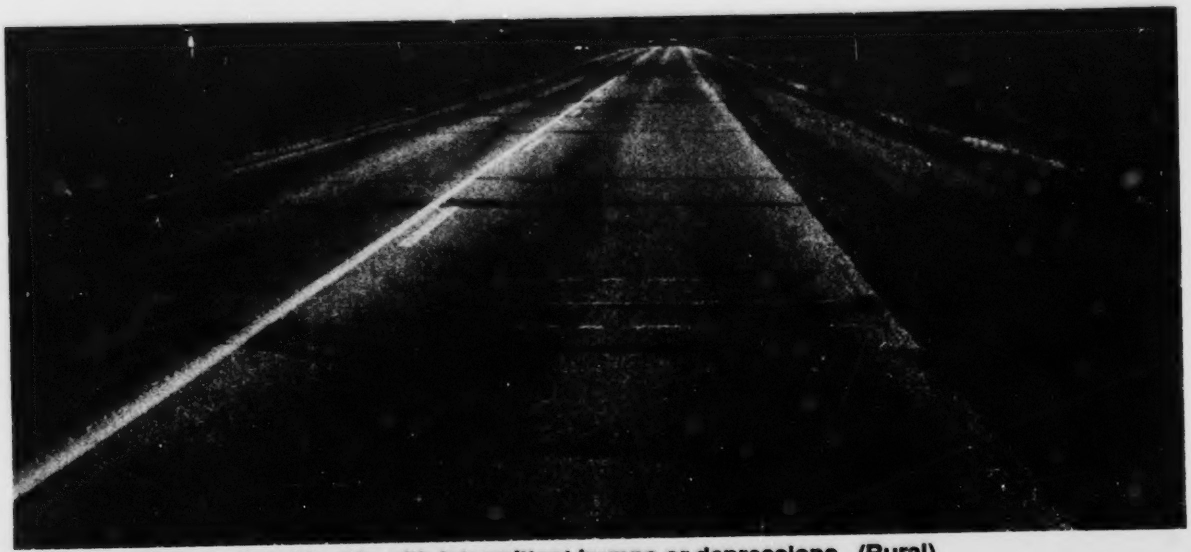
RCR Very Poor: Uncomfortable ride with constant bumps and depressions. (Urban)



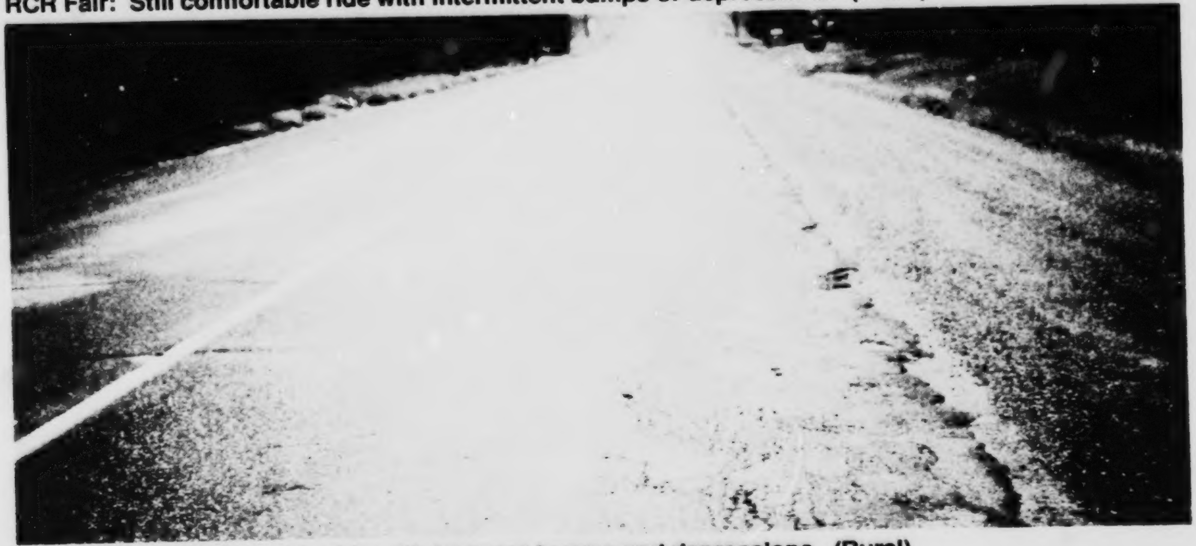
RCR Excellent: Very smooth ride. (Rural)



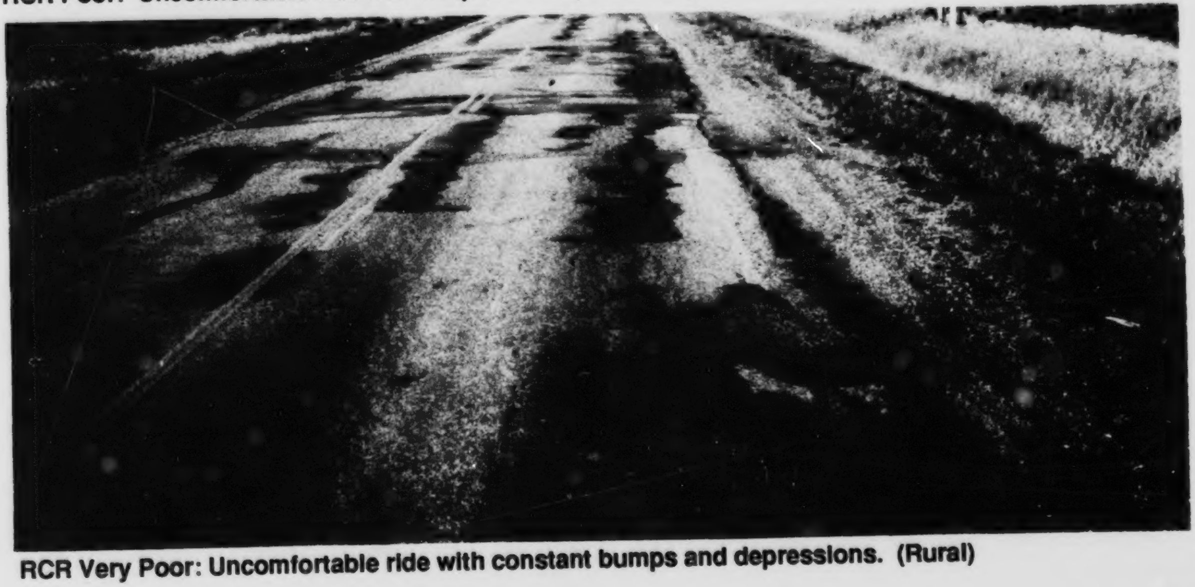
RCR Good: Smooth ride with just a few bumps or depressions. (Rural)



RCR Fair: Still comfortable ride with intermittent bumps or depressions. (Rural)



RCR Poor: Uncomfortable ride with frequent bumps and depressions. (Rural)



RCR Very Poor: Uncomfortable ride with constant bumps and depressions. (Rural)

5/ Distress Manifestation

Distress manifestations are visible signs of pavement structural condition. These distresses are indicators of problems due to material deficiencies, construction deficiencies, environmental and climatic conditions, traffic loading, or other causes. The degree of severity (How bad?) and density or extent of occurrence (How big?) of these distresses are a good indicator of the problem situation at hand [6, 7].

Severity

The term "severity" simply indicates how bad the problem is. It is a scale based on past engineering experience. It has three levels: Slight, Moderate, and Severe. These guidelines give a verbal description of each stage, along with pictorial representations.

Density (Extent of Occurrence)

The term "density" simply describes how big the problem is. It is based on past engineering experience. It has three levels: Intermittent, Frequent, and Extensive. These Guidelines give a verbal description of each stage, based on the percentage of surface area affected and where it is affected.

For example, the rater may encounter the situation where there are some potholes located within a short distance of each other and this distance within the evaluation section represents less than 20% of the pavement surface area. Thus, the "density" is said to be "intermittent" (Figure 2).

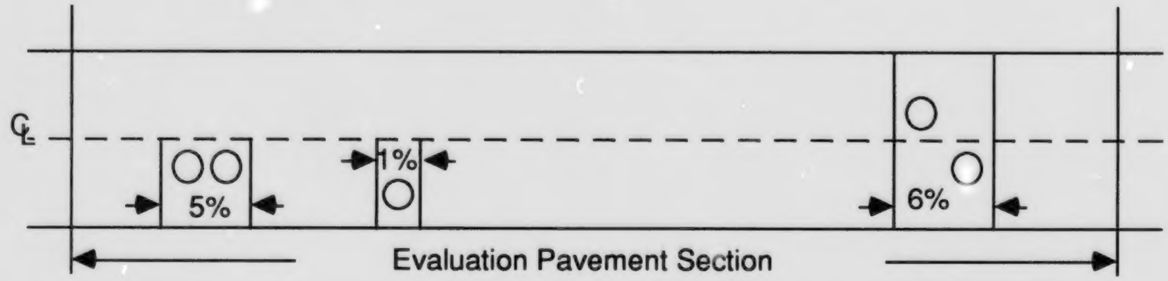


Figure 2/ Intermittent Occurrence of Potholes

On the other hand, if these same potholes are spaced over the length of the evaluation section, it is still "intermittent" because it is only isolated incidence over a few areas of the total pavement surface (Figure 3).

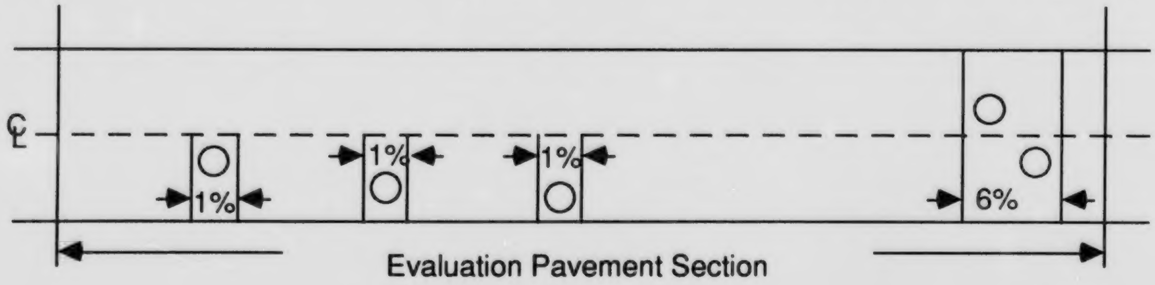


Figure 3/ Intermittent Occurrence of Potholes

However, if potholes are present in clusters covering 20 to 50% of the pavement surface, it is said to be "frequent" (Figure 4).

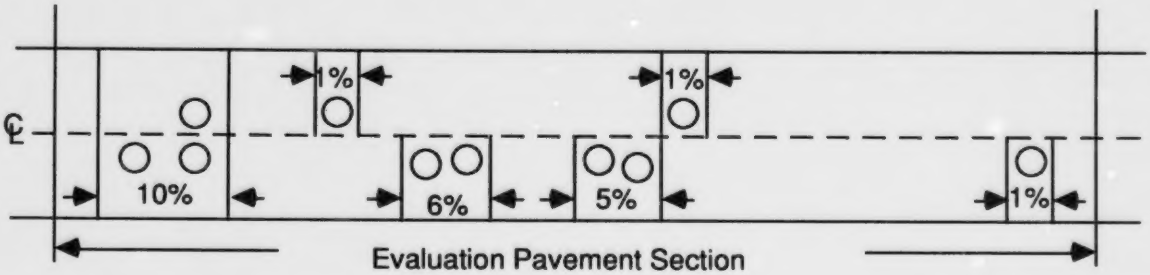


Figure 4/ Frequent Occurrence of Potholes

For "extensive" occurrence, the potholes are present over the length of the pavement section and cover more than 50% of the surface area (Figure 5).

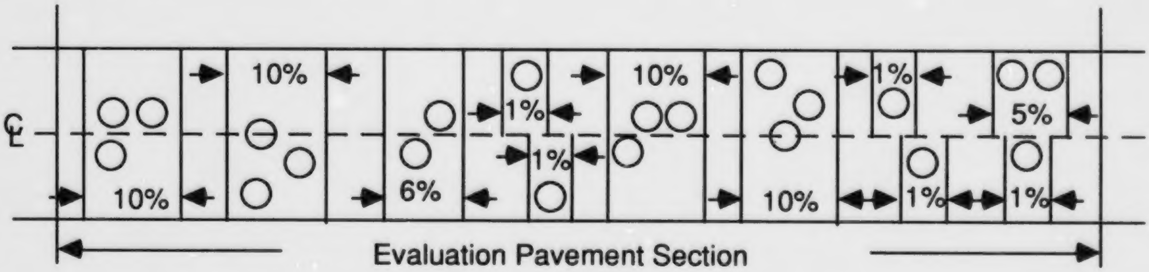


Figure 5/ Extensive Occurrence of Potholes

It should be noted that "coverage" here means that 20 to 50% of the pavement surface area has potholes. It does not mean potholes represent 20 or 50% of the pavement surface. These illustrations serve generally for all distress manifestations.

Note also that there are distresses which by nature will always remain in the "intermittent" level for density. A case in point is Manholes and Catchbasins which are placed by design and generally only a few within two urban street intersections.

5.1 / Surface Defects

Ravelling

Flushing

Potholes

Pavement Edge Breaks

Manholes and Catchbasins

Ravelling

Description:

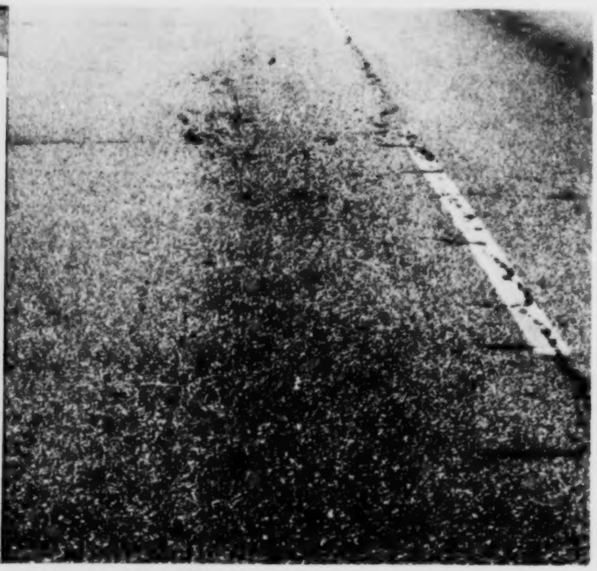
Progressive loss of pavement materials (coarse or fine aggregates, or both) from surface downward. Pavement surface looks as though it is breaking up into small pieces like pock marks. Ravelling can occur over the entire surface, but the wheel tracks are generally the worst areas because of the traffic action.

Possible causes:

1. Clay coated aggregate particles.
2. Insufficient asphalt content.
3. Poor adhesion of asphalt binder to aggregate particles due to wet aggregate.
4. Poor compaction, especially cold weather paving, permits infiltration of water and winter salts which promote freeze - thaw damage or stripping of asphalt.
5. Asphalt hardening due to aging.
6. Traffic action on a weak surface.

Severity:	**Class**	**Guidelines**
	Slight	Noticeable loss of pavement material.
	Moderate	Shallow disintegration of pavement surface; an open-textured look.
	Severe	Shallow disintegration of pavement surface with small potholes; very open-textured surface with loose materials.
Density:	Intermittent	Less than 20% of pavement surface affected; distress spotted in localized areas only.
	Frequent	20 to 50% of pavement surface affected; distress spotted evenly over entire length of pavement section or in localized areas only.
	Extensive	Greater than 50% of pavement surface affected; distress spotted throughout pavement section evenly.

Slight Ravelling



Moderate Ravelling

Severe Ravelling

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action • Fog Seal
	Extensive	• Fog Seal
Moderate	Intermittent	• Manual Spray Patching • Manual Chip Seal
	Frequent	• Manual Chip Seal
	Extensive	• Manual Chip Seal • Machine Chip Seal • Fog Seal • Surface Treatment • No action but place on Rehabilitation Program
Severe	Intermittent	• Manual Chip Seal
	Frequent	• Manual Chip Seal • Machine Chip Seal • Machine Patching • No action but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

Flushing

Description:

Free asphalt migrating upward to the pavement surface. Most likely to occur in the wheel tracks, especially during hot weather.

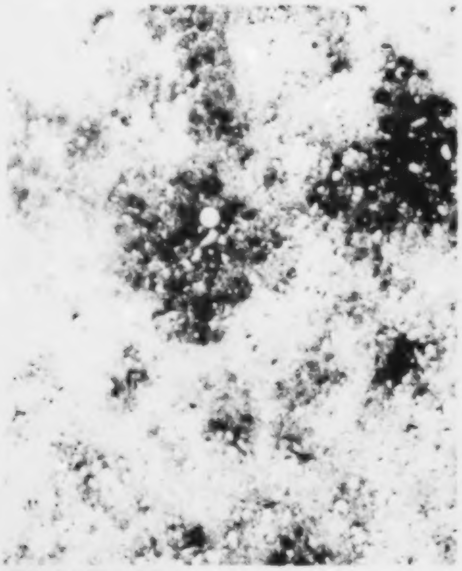
Possible causes:

1. Too much asphalt in the mix relative to the void space in mineral aggregate. On hot days, asphalt expands into air voids; if the air voids are too low, continued expansion results in a densification of the mix under traffic which forces excess asphalt to the surface.

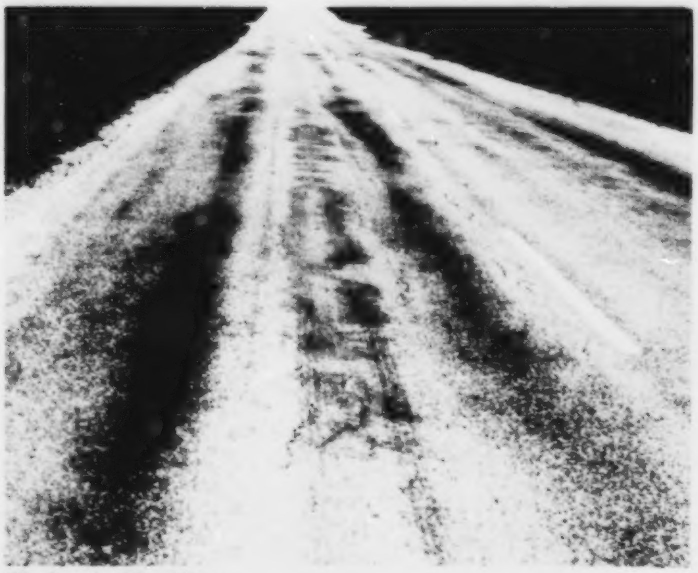
2. Paving over excess primed surfaces.

Severity:	**Class**	**Guidelines**
	Slight	Colouring of pavement surface visible (inter-connected veining).
	Moderate	Distinctive appearance (with excess asphalt already free).
	Severe	Free asphalt gives the pavement surface a wet look; tire marks and tracking are evident; tire noise can be heard.

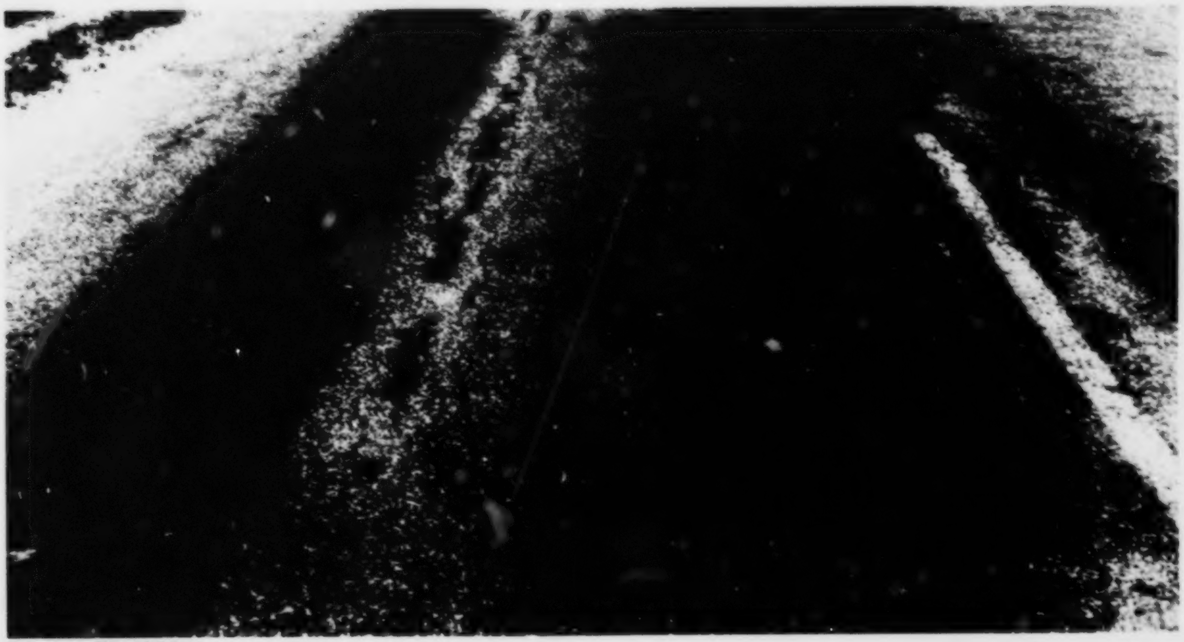
Density:	Intermittent	Less than 20% of pavement surface (wheel tracks) affected; distress spotted in localized areas only.
	Frequent	20 to 50% of pavement surface (wheel tracks) affected; distress spotted evenly over the length of the pavement section or in localized areas only.
	Extensive	Greater than 50% of pavement surface (wheel tracks) affected; distress spotted over the length of pavement section.



Slight Flushing



Moderate Flushing



Severe Flushing

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action but place on Rehabilitation Program
Severe	Intermittent	• No action • Manual Burn and Seal • Cold Mill and replacement by Hot Mix Patching
	Frequent	• Cold Mill and replacement by Hot Mix Patching • No action but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

Potholes

Description:

Round or irregular shaped holes in pavement; can be unrelated to other surface defects or a direct result of other defects such as ravelling, alligator cracking, etc; can be related to utilities such as manholes, catchbasins, etc.

Possible causes:

1. Poor construction technique and poor quality control.
2. Poor aggregates in pavement.
3. Result of other defects (ravelling, cracking, alligator cracking, etc.)
4. Result of defects around manholes, catchbasins, utilities.
5. Inadequate structural thickness.

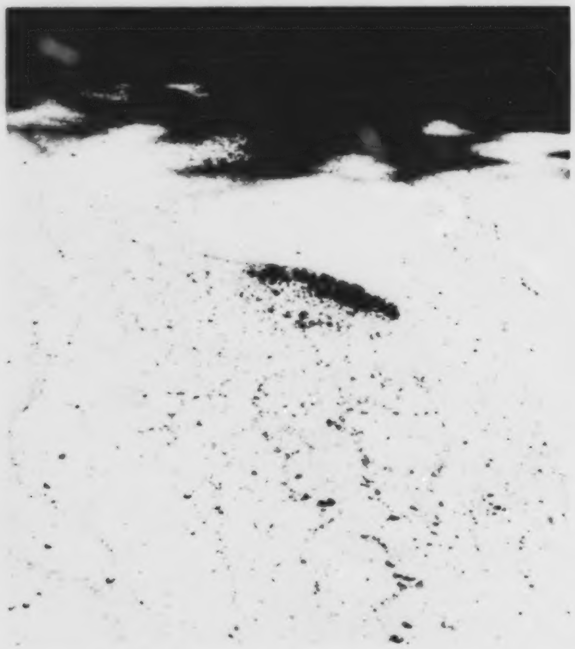
Severity:

Class	Guidelines
Slight	Small (≤100 mm in diameter) and shallow in depth.
Moderate	100 to 300 mm wide and usually more than 50 mm deep.
Severe	More than 300 mm wide and usually more than 100 mm deep.

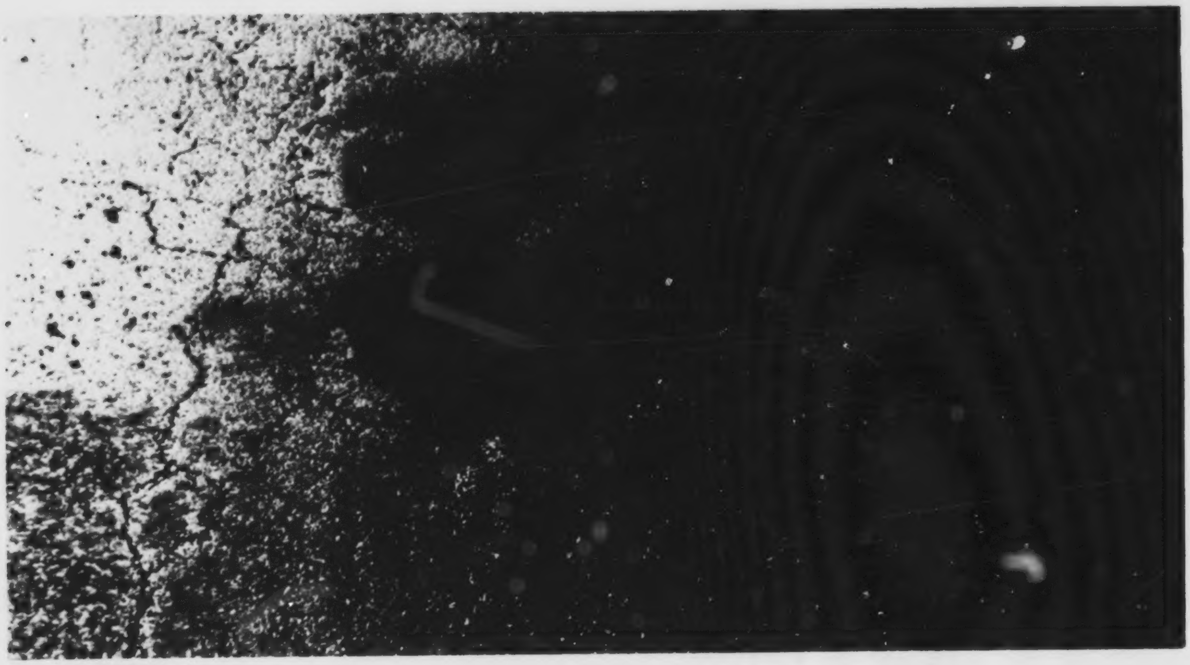
Density:

Intermittent	Less than 20% of pavement surface affected; distress spotted in localized area only.
Frequent	20 to 50% of pavement surface affected; distress spotted evenly over length of pavement section or in localized areas only.
Extensive	Greater than 50% of pavement surface affected; distress spotted evenly over length of pavement section.

Slight Pothole



Moderate Pothole


Severe Pothole

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• Manual Spray Patching • Manual Chip Seal • Manual Patching
	Frequent	• Manual Spray Patching • Manual Chip Seal
	Extensive	• Manual Patching
Moderate	Intermittent	• Manual Patching
	Frequent	• Manual Patching
	Extensive	• Manual Patching and place on Rehabilitation Program
Severe	Intermittent	• Manual Patching
	Frequent	• Manual Patching and place on Rehabilitation Program
	Extensive	• Rehabilitation now or within a year

Pavement Edge Breaks

Description:

Edge breaking occurs with or without cracks; it generally occurs in thin hot-mix, mulch or surface-treatment types of pavement surfaces.

Possible causes:

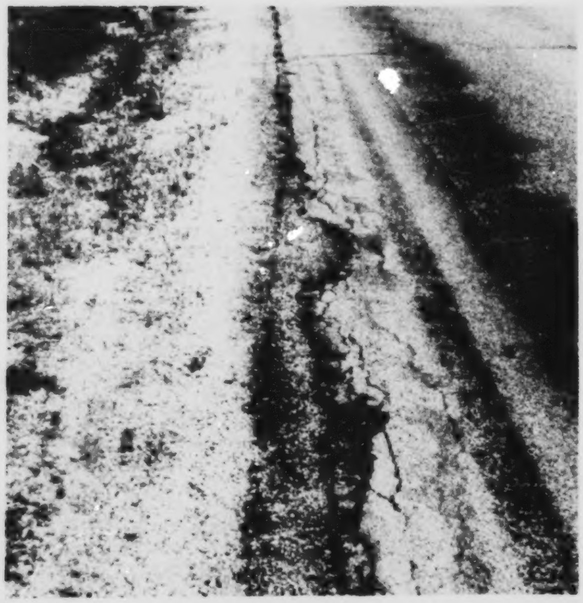
1. Frost action.
2. Insufficient bearing support or excessive traffic loading at the pavement edge.
3. Poor drainage at pavement edge and shoulder.
4. Inadequate pavement width forces traffic too close to pavement edge.

Severity:

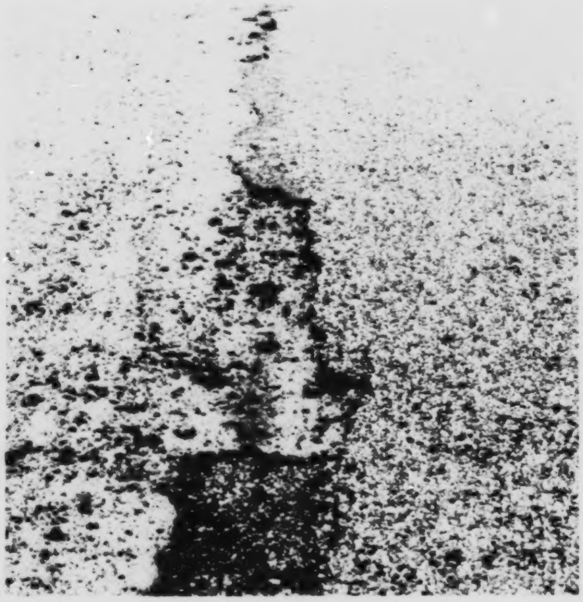
Class	Guidelines
Slight	Small breaks (less than 26 mm) from pavement edge; no missing pieces or very few missing pieces.
Moderate	Breaks between 26 and 75 mm from pavement edge; pieces missing giving pavement edge jagged look.
Severe	Large breaks (greater than 75 mm) from pavement edge; large pieces missing from pavement edge.

Density:

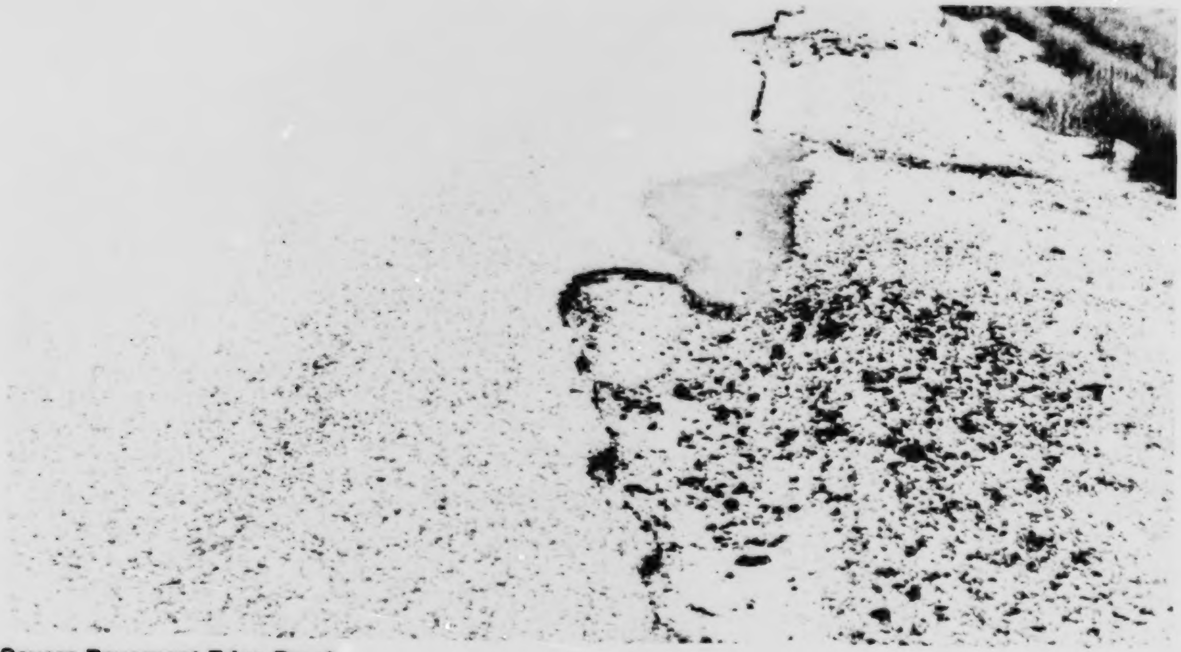
Intermittent	Less than 20% of pavement edge affected; distress spotted in localized areas only.
Frequent	20 to 50% of pavement edge affected; distress spotted evenly over length of pavement section or in localized areas.
Extensive	Greater than 50% of pavement edge affected; distress spotted evenly over length of pavement section.



Slight Pavement Edge Break



Moderate Pavement Edge Break



Severe Pavement Edge Break

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• Manual Patching
	Frequent	• Manual Patching
	Extensive	• No action but place on Rehabilitation Program
Severe	Intermittent	• Manual Patching
	Frequent	• No action but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

Manholes and Catchbasins

Description:

Depressed or protruding manholes and catchbasins with or without cracks. It results in deformation of the immediate area in the form of a bump or dip, which gives rise to jarring roughness in a moving vehicle. Manholes represent more of a problem than catchbasins because in most cases they are on the travelled portion of the pavement surface. This problem is unique to urban areas of municipalities.

Possible causes:

1. Differential frost heave of the manholes or catchbasins, and the pavement structure.
2. Differential settlement of the manholes or catchbasins, and the pavement structure.
3. Traffic action.

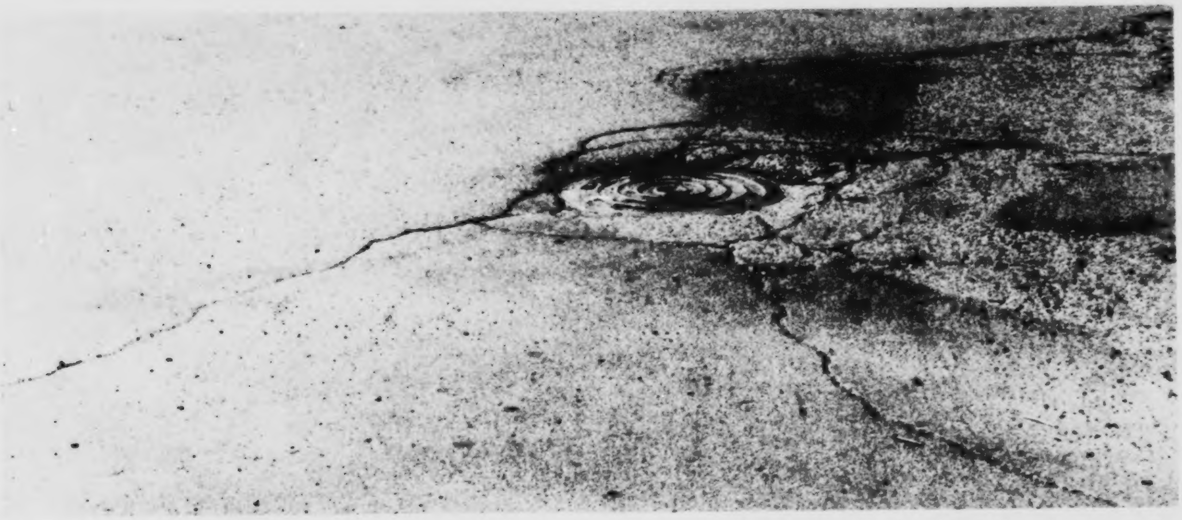
Severity:

Class	Guidelines
Slight	Noticeable bump or drop of vehicle while in motion. Bump or drop less than 15 mm; with or without cracks.
Moderate	Harsh bump or drop of vehicle while in motion. Bump or drop 15 to 25 mm; with or without cracks.
Severe	Hard bump or drop of vehicle while in motion. Bump or drop greater than 25 mm; with or without cracks.

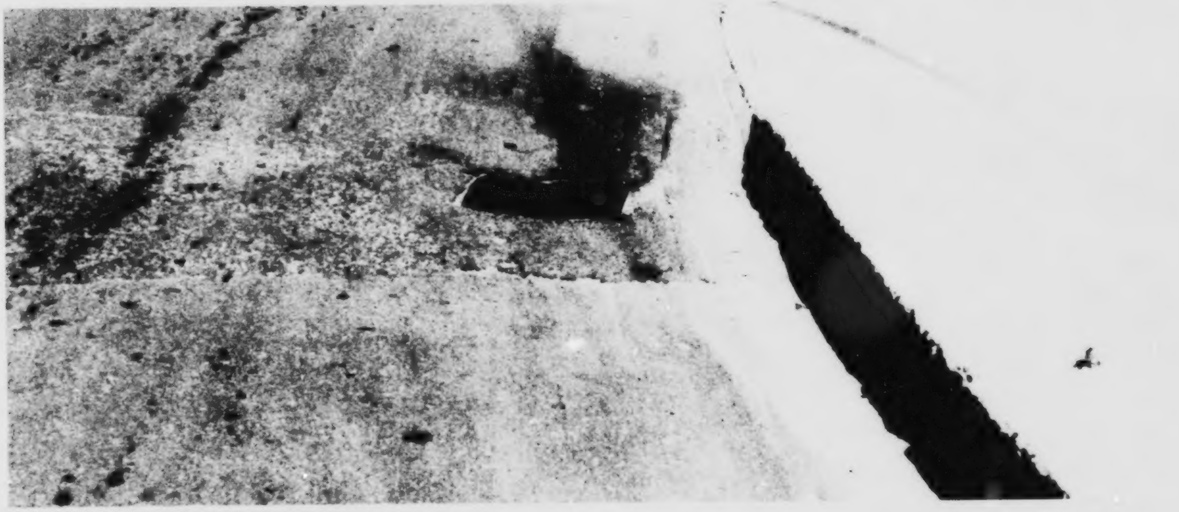
Density:

Intermittent	Less than 20% of pavement surface affected; distress spotted in localized areas or evenly spread over length of pavement section.
Frequent	Not applicable
Extensive	Not applicable

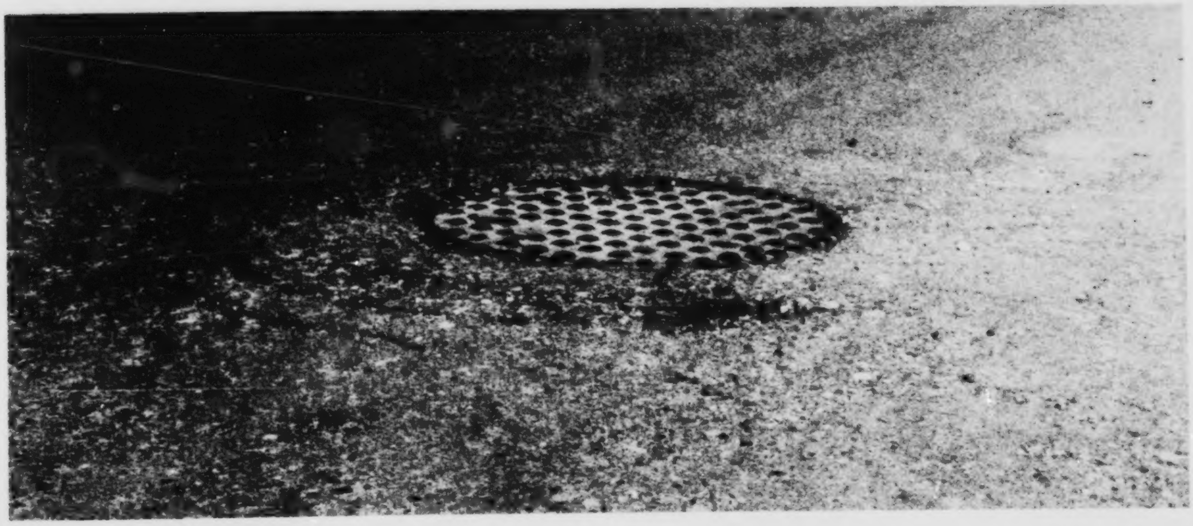
Slight Manhole Depression



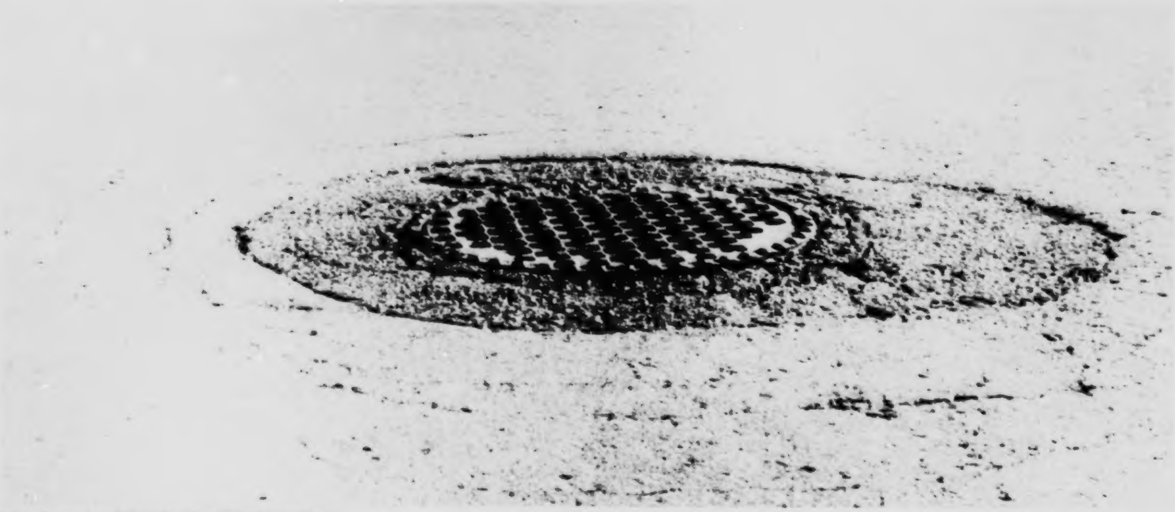
Moderate Manhole Depression



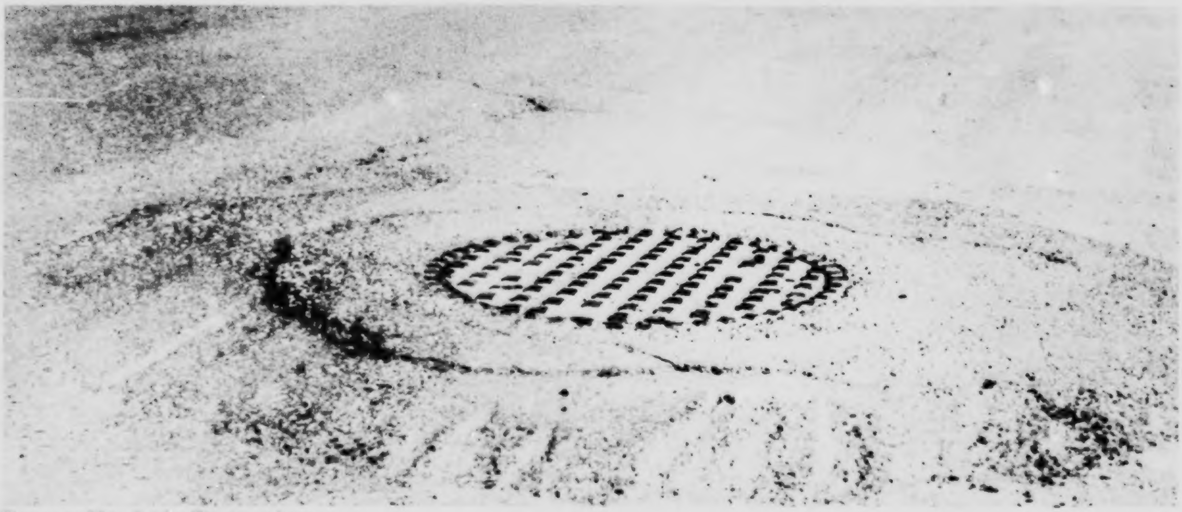
Severe Catchbasin Depression



Slight Manhole Protrusion



Moderate Manhole Protrusion



Severe Manhole Protrusion

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No Treatment
Moderate	Intermittent	• No Treatment • Cold Mill or excavate pavement around Manhole or Catchbasin and build up with bricks or concrete ring(s) if depressed. • Cold Mill or excavate pavement around Manhole or Catchbasin and remove excess height if protruding.
Severe	Intermittent	• Treatment as above

5.2/ Surface Deformation

Rippling and Shoving

Wheel Track Rutting

Distortion

Utility Trenches

Rippling and Shoving

Description: Regular transverse undulations in the pavement surface consisting of closely spaced alternate valleys and crests (washboard effect).

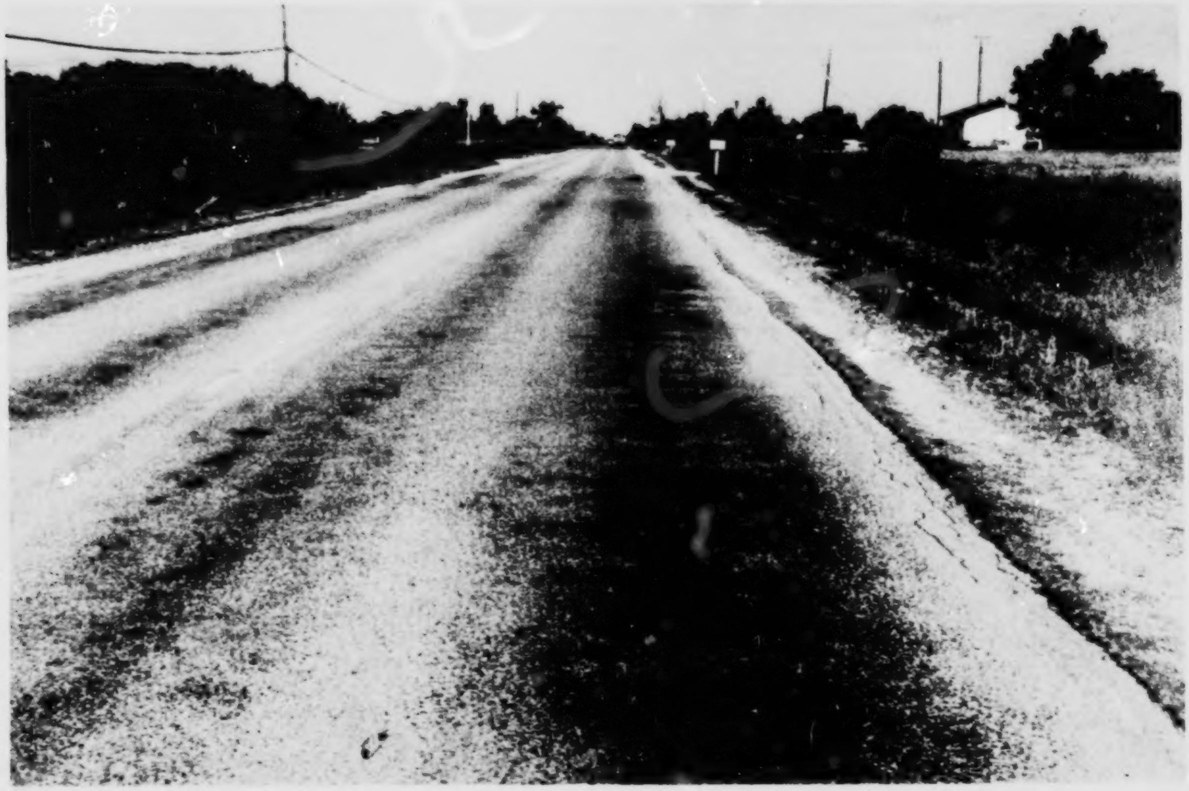
Possible causes:

1. Faulty paver behaviour with some asphalt mixes.
2. Low stability in asphalt mix.
3. Traffic action, such as stop and start at intersections.

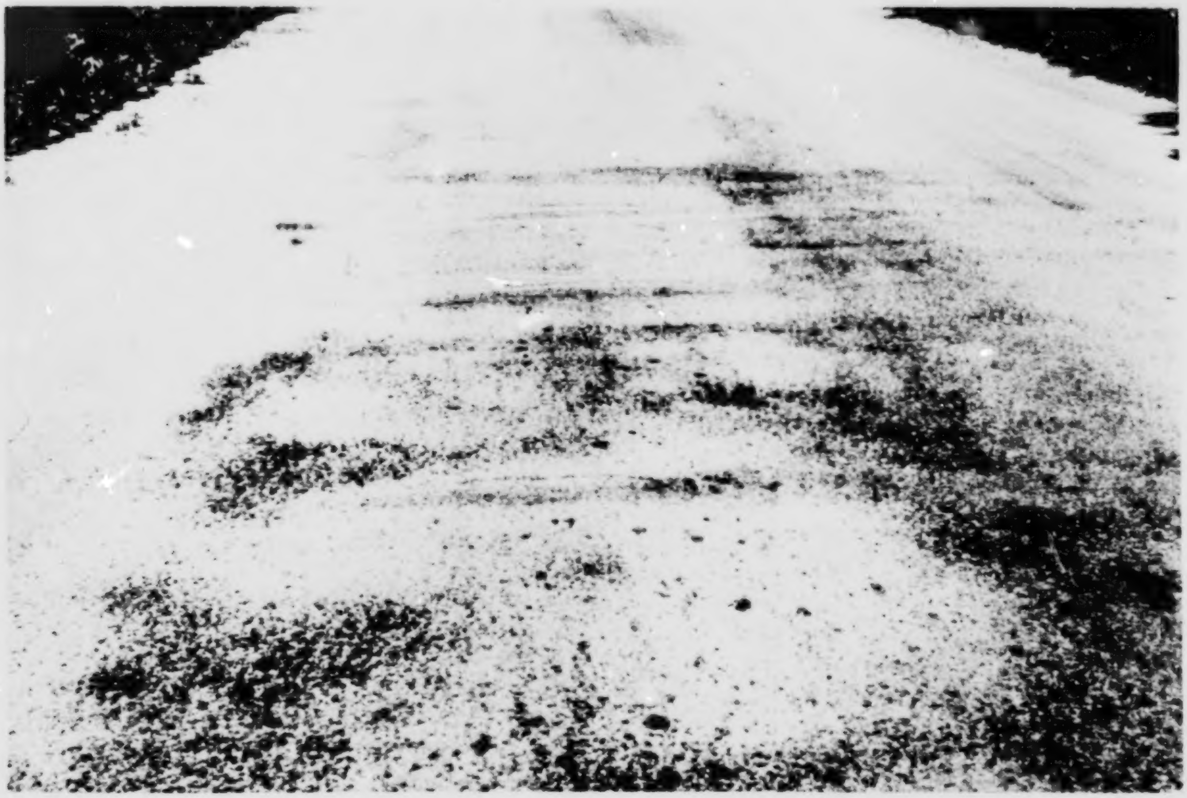
Severity:	**Class**	**Guidelines**
	Slight	Noticeable washboard effect.
	Moderate	Bumpy with washboard appearance or ridges and valleys.
	Severe	Very bumpy with pronounced washboarding or large humps on pavement surface.

Density:		
	Intermittent	Less than 20% of pavement surface affected; distress spotted in localized areas only.
	Frequent	20 to 50% of pavement surface affected; distress spotted evenly over length of pavement section or in localized areas only.
	Extensive	Greater than 50% of pavement surface affected; distress spotted evenly over length of pavement section.

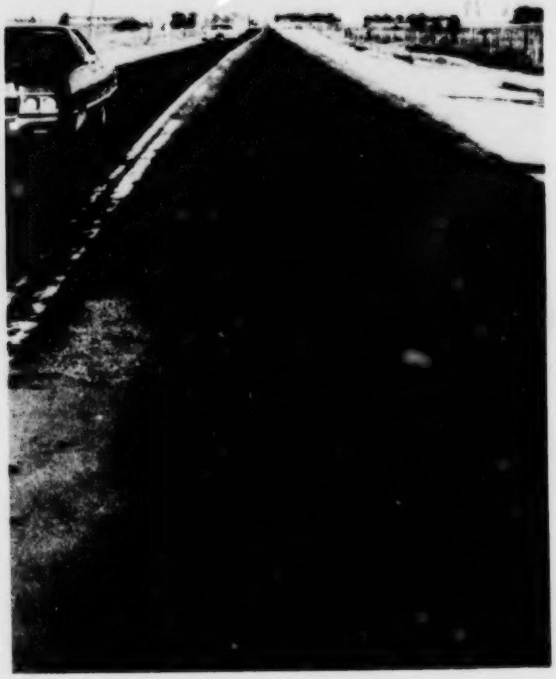
Slight Rippling



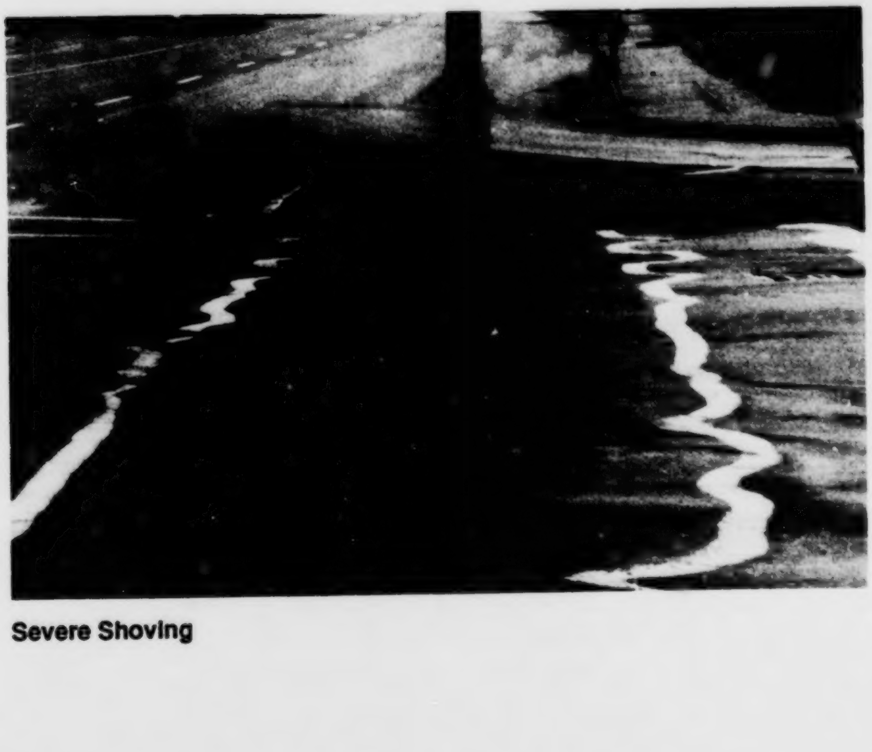
Moderate Rippling



Moderate Shoving



Severe Rippling



Severe Shoving

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• Cold Milling or Hot Planing with Manual Patching • Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Frequent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Extensive	• Machine Patching • Cold Milling or Hot Planing with Machine Patching • No action but place on Rehabilitation Program
Severe	Intermittent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Frequent	• Rehabilitation Program
	Extensive	• Rehabilitation Program

Wheel Track Rutting

Description:

Longitudinal depression left in the wheel tracks after repeated load application. It results from densification and permanent deformation under load combined with displacement of pavement materials. Deep ruts are often accompanied by longitudinal cracking in the wheel tracks.

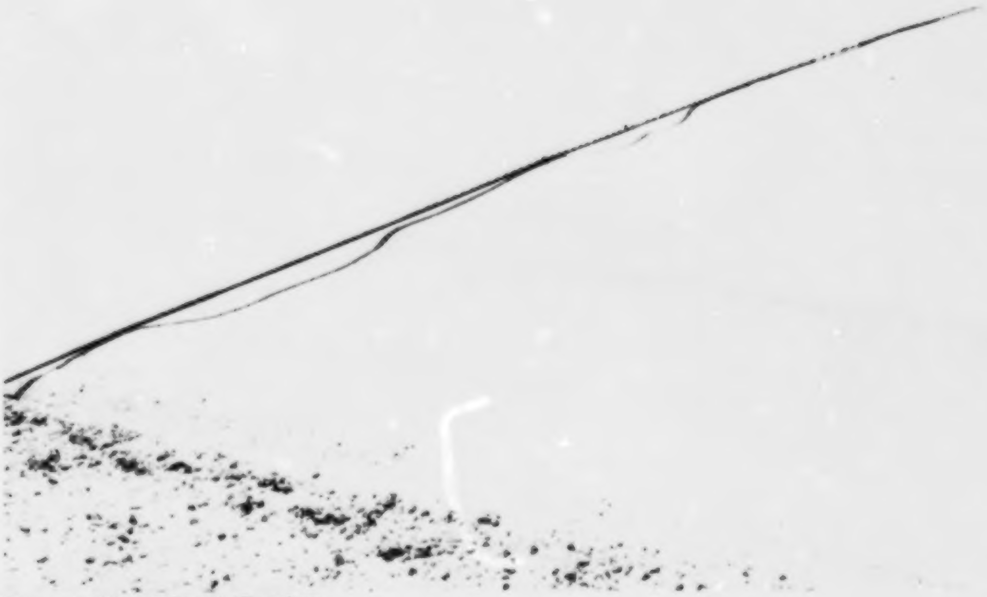
Possible causes:

1. Poorly compacted structural layers.
2. Unstable granular bases or subbases created by positive pore water pressures under loads at times of near saturation.
3. Unstable asphalt mixes (due to high temperatures, high asphalt content, low viscosity of binder, etc.).
4. Unstable granular shoulder; does not provide adequate lateral support.
5. Over-stressed subgrade will deform permanently.

	Class	Guidelines
Severity:	**Class**	**Guidelines**
	Slight	Less than 15 mm with or without single longitudinal crack based on a 1.3 m baseline.
	Moderate	15 to 25 mm with or without single longitudinal crack (may begin to have multiple longitudinal cracks).
	Severe	Greater than 25 mm with or without single longitudinal crack or multiple longitudinal cracks based on a 1.3 m baseline.
Density:	Intermittent	Less than 20% of wheel tracks affected.
	Frequent	20 to 50% of wheel tracks affected.
	Extensive	Greater than 50% of wheel tracks affected.

Slight Wheel Track Rutting

Moderate Wheel Track Rutting



Severe Wheel Track Rutting

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• Manual Chip Seal • Machine Chip Seal • Machine Patching
	Frequent	• Manual Chip Seal • Machine Chip Seal • Machine Patching
	Extensive	• Machine Chip Seal • Machine Patching • No action but place on Rehabilitation Program
Severe	Intermittent	• Machine Patching
	Frequent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Extensive	• Machine Patching • Cold Milling or Hot Planing with Machine Patching • Rehabilitation Program

Distortion

Description:

Any deviation of the pavement surface from its original shape (other than described for rippling, shoving and rutting). Generally, these distortions result from settlement, slope failure, volume changes due to moisture and frost heaving, residual effects of frost heaving accumulating after each winter. The resulting deformation may take the form of dishing, bumps, dips, lipping or stepping at cracks, all of which give rise to pitch, roll and jarring drop in a moving vehicle.

Possible causes:

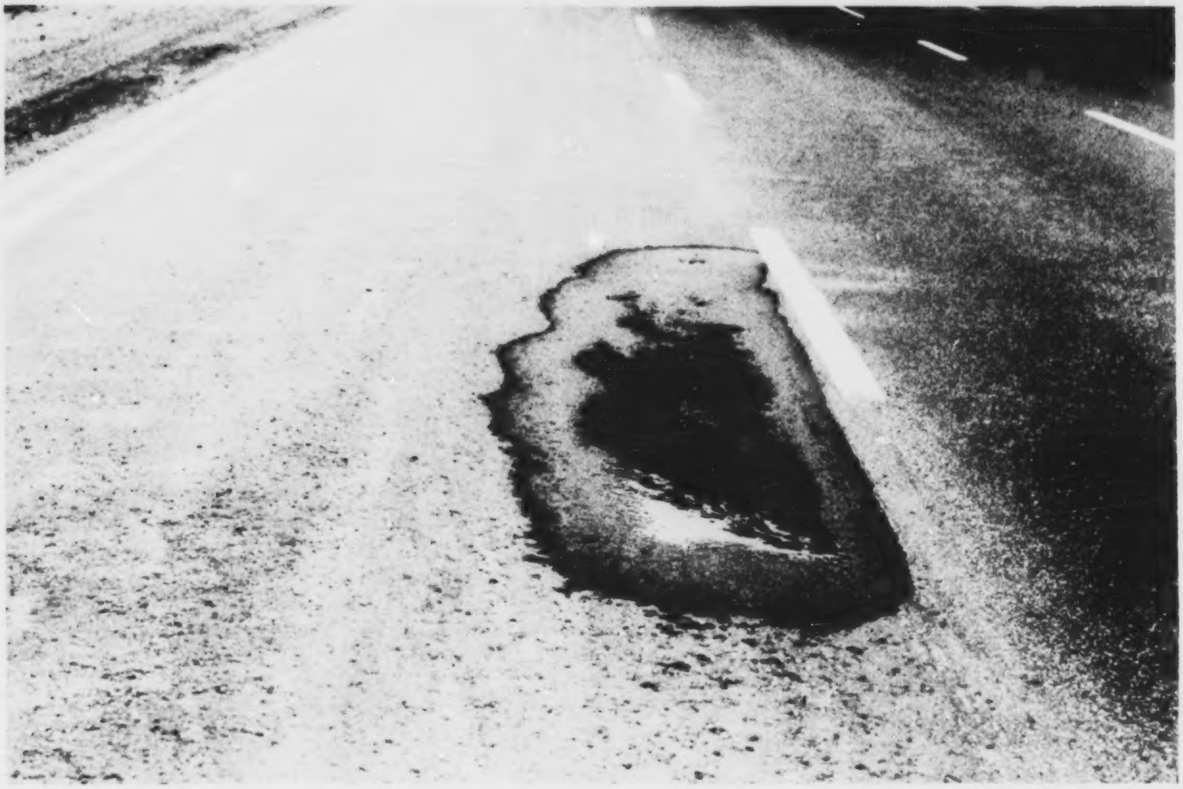
1. Differential frost heave in poorly drained cuts and transitions.
2. Differential frost heave at pavement edges, road centre, pavement cracks, edges of manholes and catchbasins.
3. Reverse differential frost heave at culverts.
4. Differential settlement of subgrade or base materials.
5. Lack of subgrade support.
6. Embankment slope failure.
7. Improper maintenance.

Severity:

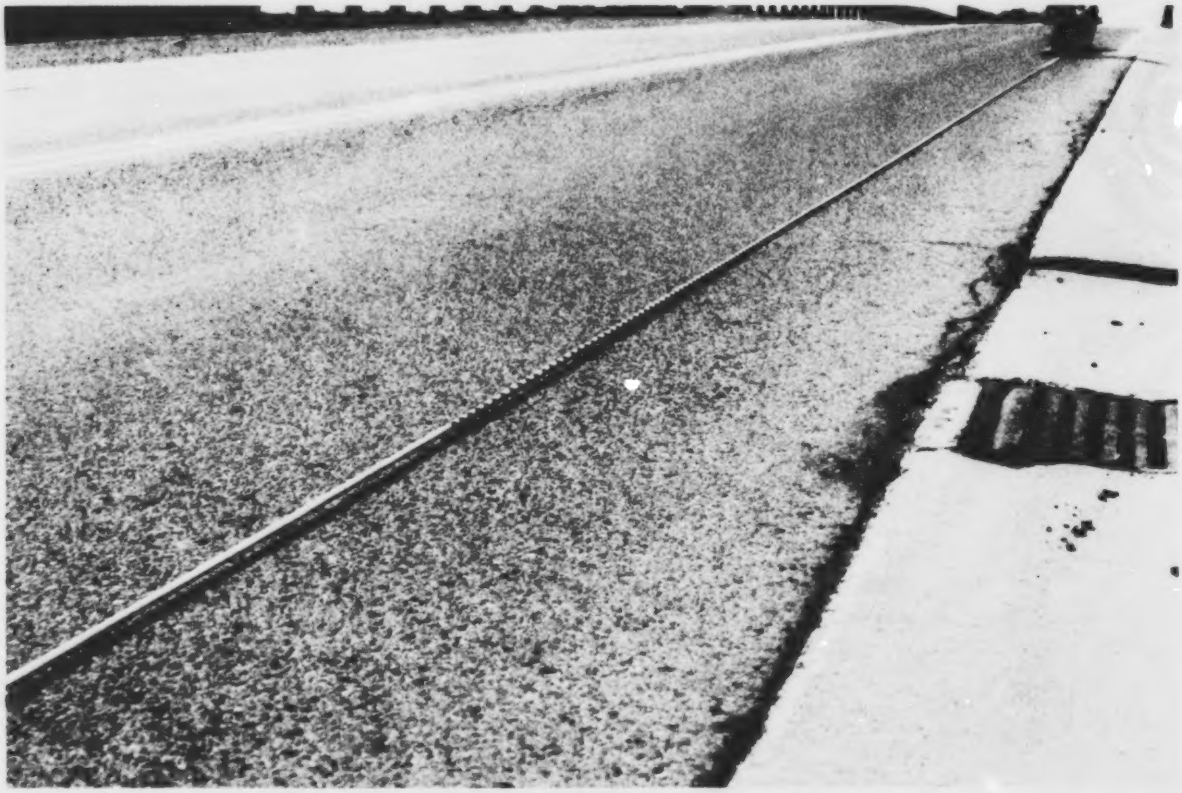
Class	Guidelines
Slight	Barely noticeable pitch and roll, and jarring bump or drop of vehicle while in motion.
Moderate	Noticeable pitch and roll, and harsh jarring bump or drop of vehicle while in motion.
Severe	Continuous pitch and roll, and hard jarring bump or drop of vehicle while in motion; driver always has to anticipate distortion ahead and feels it necessary to reduce speed.

Density:

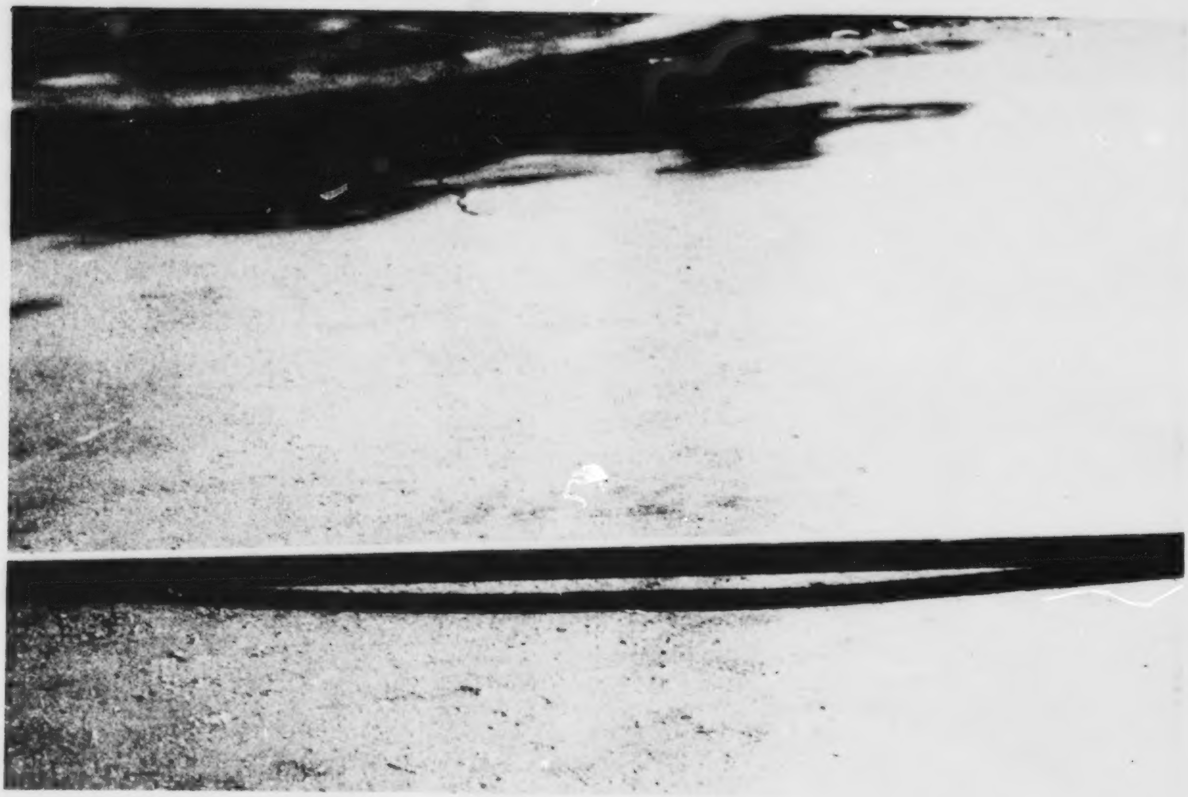
Intermittent	Less than 20% of pavement surface is affected; distress spotted in localized areas only.
Frequent	20 to 50% of pavement surface affected; distress spotted evenly over length of pavement section or in localized areas only.
Extensive	Greater than 50% of pavement surface affected; distress spotted evenly over length of pavement section.



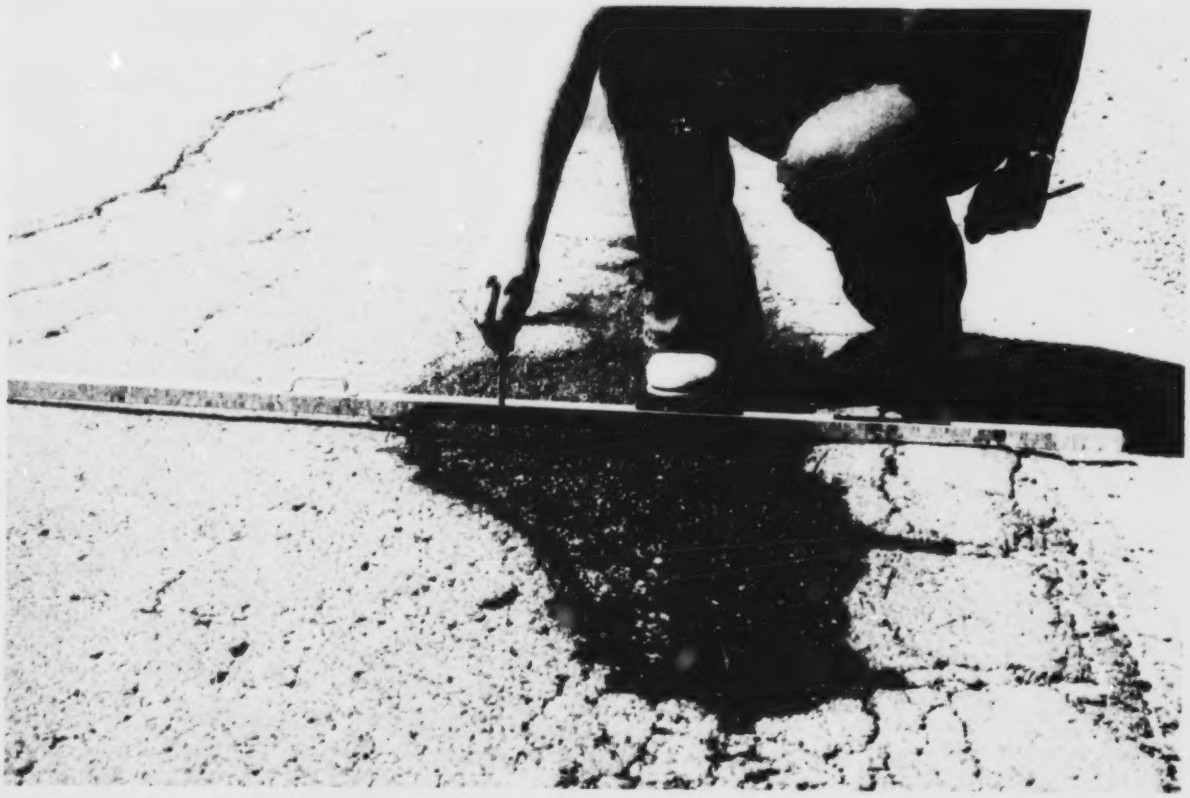
Slight Distortion



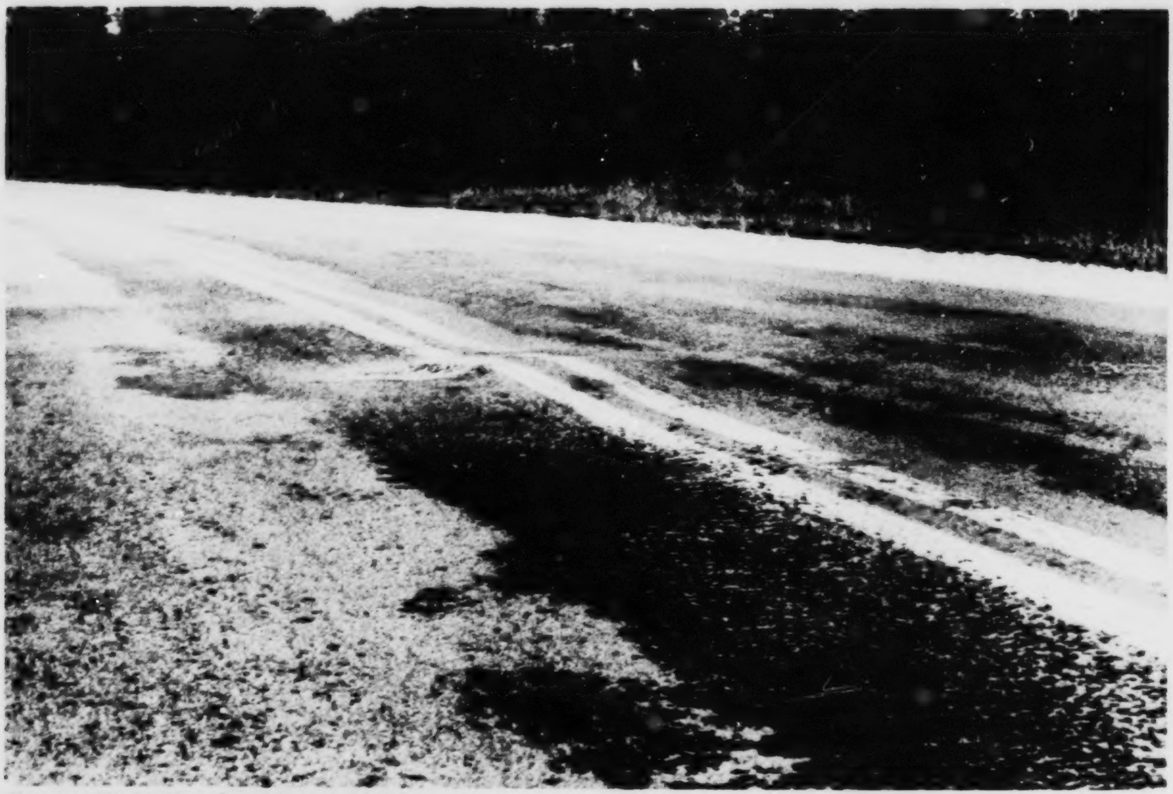
Moderate Longitudinal Distortion from Settlement



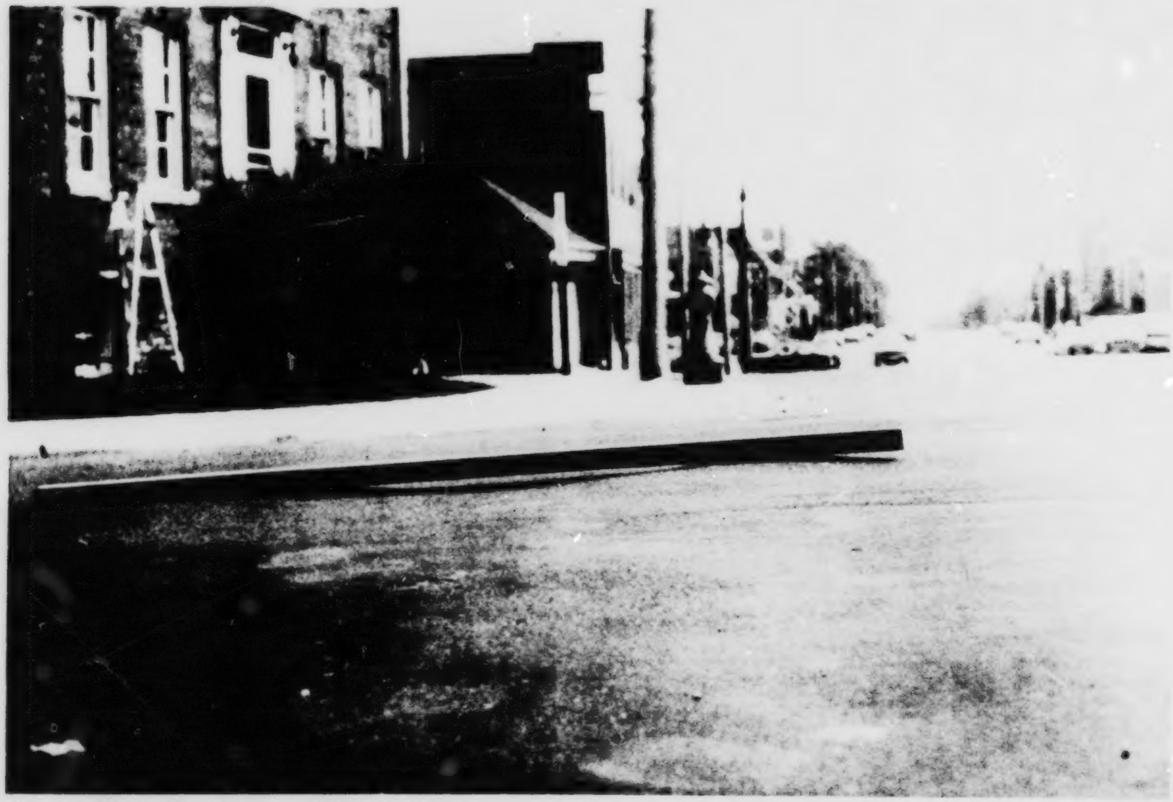
Severe Distortion from Lack of Structural Strength



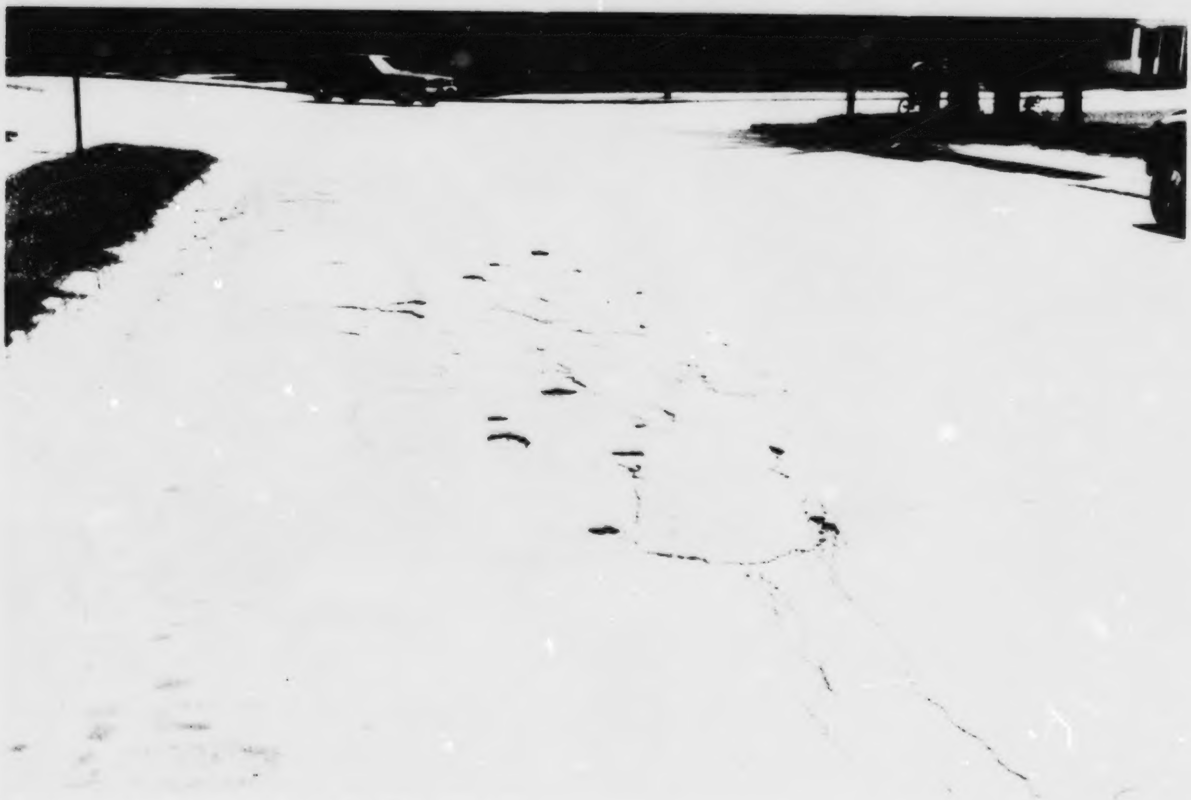
Severe Distortion from Lack of Structural Strength



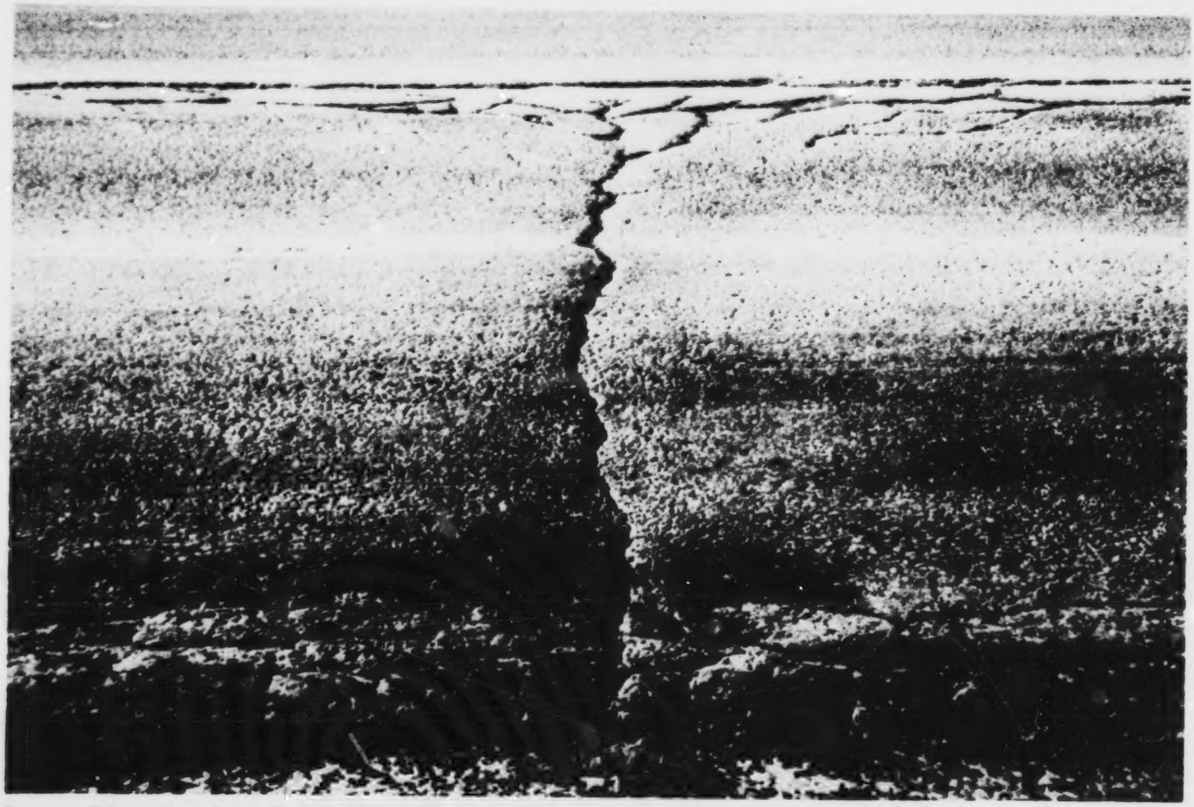
Severe Distortion from Frost Action



Severe Distortion from Traffic Loading



Severe Distortion from Improper Maintenance



Severe Distortion from Frost Action (Transverse Crack Lipping due to Frost Action)

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• Manual Patching • Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Frequent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Extensive	• No action but place on Rehabilitation Program
Severe	Intermittent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Frequent	• Rehabilitation Program
	Extensive	• Rehabilitation Program

Utility Trenches

Description:

Utility cuts in the pavement of urban roads and streets are a problem unique to municipalities. In some cases, streets can become scarred from many cuts and patches for utility connections. Therefore, although "utility trenches" are not a pavement distress manifestation, they are a very important factor in overall pavement performance.

Deviations of the pavement surface result from excavation of trenches for utilities. The deformation may take the form of bumps, dips, potholes and breakup, all of which give rise to pitch, roll, and jarring drop in a moving vehicle.

Possible causes:

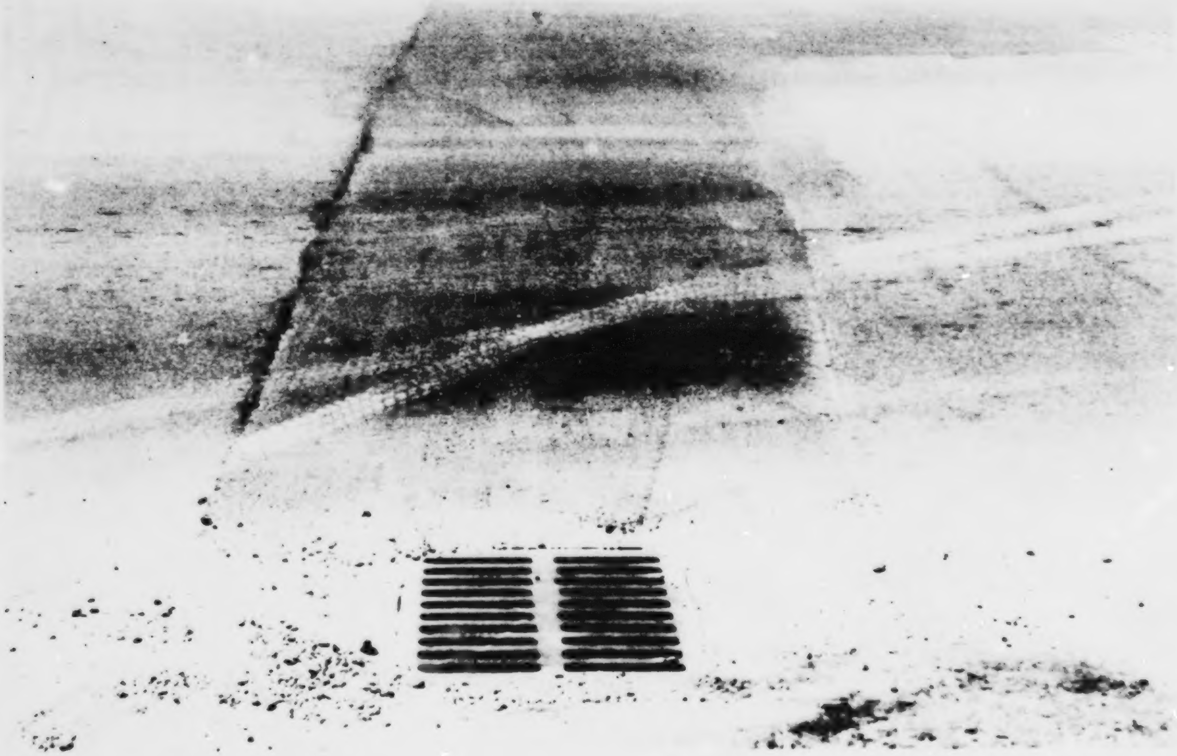
1. Differential frost heave in poorly drained trenches.
2. Poor compaction of backfill resulting in settlement of trenches.
3. Differential settlement of subgrade or base materials in trenches.
4. Excess backfill material and patching material for trenches resulting in bump.
5. Lack of subgrade support.
6. Poor patching material for trenches and improper work procedures for trench backfill and patch.
7. Traffic action.

Severity:

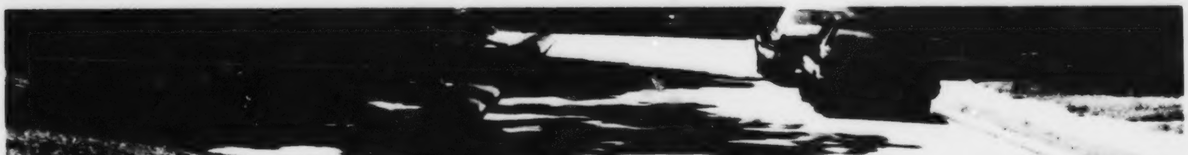
Class	Guidelines
Slight	Rise or depression of ≤15 mm with or without cracking. Barely noticeable jarring drop or bump of vehicle while in motion.
Moderate	Rise or depression of 16 to 25 mm with or without cracks, cracking might be multiple or beginning to alligator. Harsh jarring drop or bump of vehicle while in motion.
Severe	Rise or depression greater than 25 mm with multiple or alligator cracking, might have potholes. Hard jarring drop or bump of vehicle while in motion.

Density:

Intermittent	Less than 20% of pavement surface is affected by distress from utility trenches.
Frequent	20 to 50% of pavement surface is affected by distress from utility trenches.
Extensive	Greater than 50% of pavement surface is affected by distress from utility trenches.



Slight Utility Cut



Moderate Utility Cut

Severe Utility Cut

Severe Utility Cut

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• Manual Patching • Cold Milling or Hot Planing with Machine Patching
	Frequent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching
	Extensive	• No action but place on Rehabilitation Program
Severe	Intermittent	• Manual Patching • Cold Milling or Hot Planing with Manual Patching
	Frequent	• Machine Patching • Cold Milling or Hot Planing with Machine Patching • Rehabilitation Program
	Extensive	• Rehabilitation Program

*** Note:**

Settlement of backfill in utility cuts is usually caused by poor compaction practices. One major municipality addresses this problem by using an "unshrinkable fill" lean concrete as a base layer in the backfill.

5.3/ Cracking

Longitudinal Cracking

Transverse Cracking

Pavement Edge Cracking

Map Cracking

Alligator Cracking

Longitudinal Cracking

Description:

Cracks follow a course approximately parallel to the direction of travel and are situated at or near the centre of the wheel tracks, centreline, mid-lane, etc.

Possible causes:

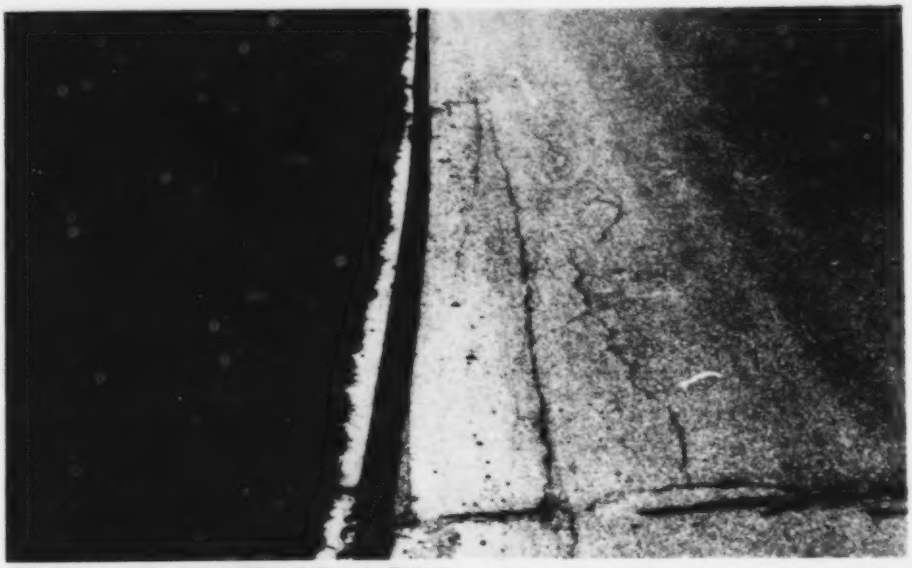
1. Traffic action (loading) combined with weak pavement.
2. Poor construction equipment and/or technique.
3. Environmental and climatic conditions (frost action, moisture changes, etc.).

Severity:

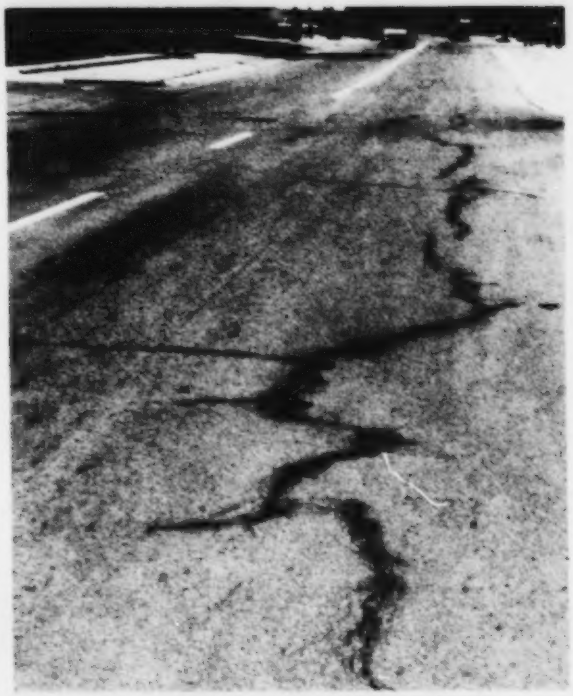
Class	Guidelines
Slight	2 to 12 mm single crack.
Moderate	13 to 19 mm single crack, or multiple cracks (even if crack opening is less than 13 mm).
Severe	20 mm plus single crack, or multiple cracks which begin to develop spalling (even if crack opening is less than 20 mm).

Density:

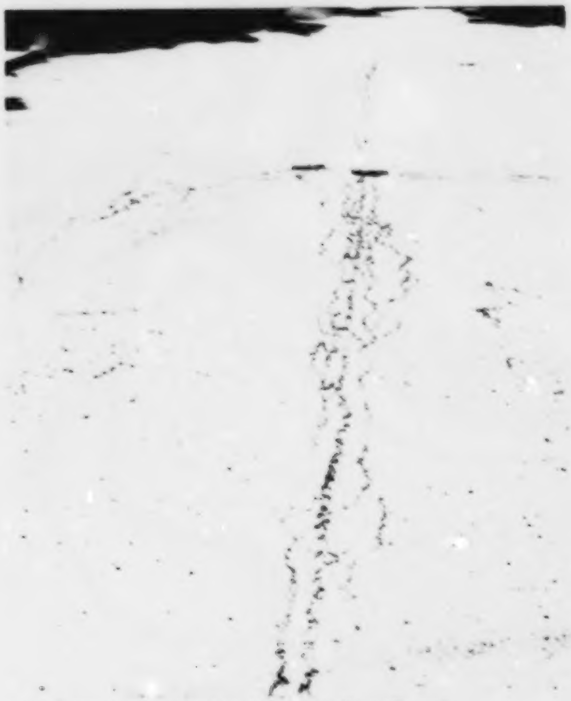
Intermittent	Less than 20% of pavement surface affected; distress spotted in localized areas only.
Frequent	20 to 50% of pavement surface affected; distress spotted evenly over length of pavement section or in localized areas only.
Extensive	Greater than 50% of pavement surface affected; distress spotted evenly over length of pavement section.



Slight Longitudinal Wheel Track Crack



Moderate Longitudinal Meandering Crack



Severe Longitudinal Centreline Crack

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• Rout and seal all cracks if pavement is composite type (asphalt over concrete) • Rout and seal if crack is >6 mm when pavement is asphalt only
	Frequent	• Same as above
	Extensive	• Same as above
Moderate	Intermittent	• Rout and seal if crack is single without multiple cracking or with only minor amount of multiple cracking
	Frequent	• Same as above
	Extensive	• No action but place on Rehabilitation Program
Severe	Intermittent	• No action
	Frequent	• No action but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

Transverse Cracking

Description:

Crack follows a course approximately at right angles to the pavement centreline. In a rural situation, full width transverse cracks tend to be regularly spaced along the length of the road, while half width transverse and part transverse cracks occur at shorter intermediate distances.
In an urban situation, transverse cracks tend to be full width and spaced more randomly.

Possible causes:

1. Natural shrinkage caused by very low temperatures.
2. High temperature susceptibility of asphalt cement binder in asphalt mixes.
3. Frost action.
4. Reflection cracks.

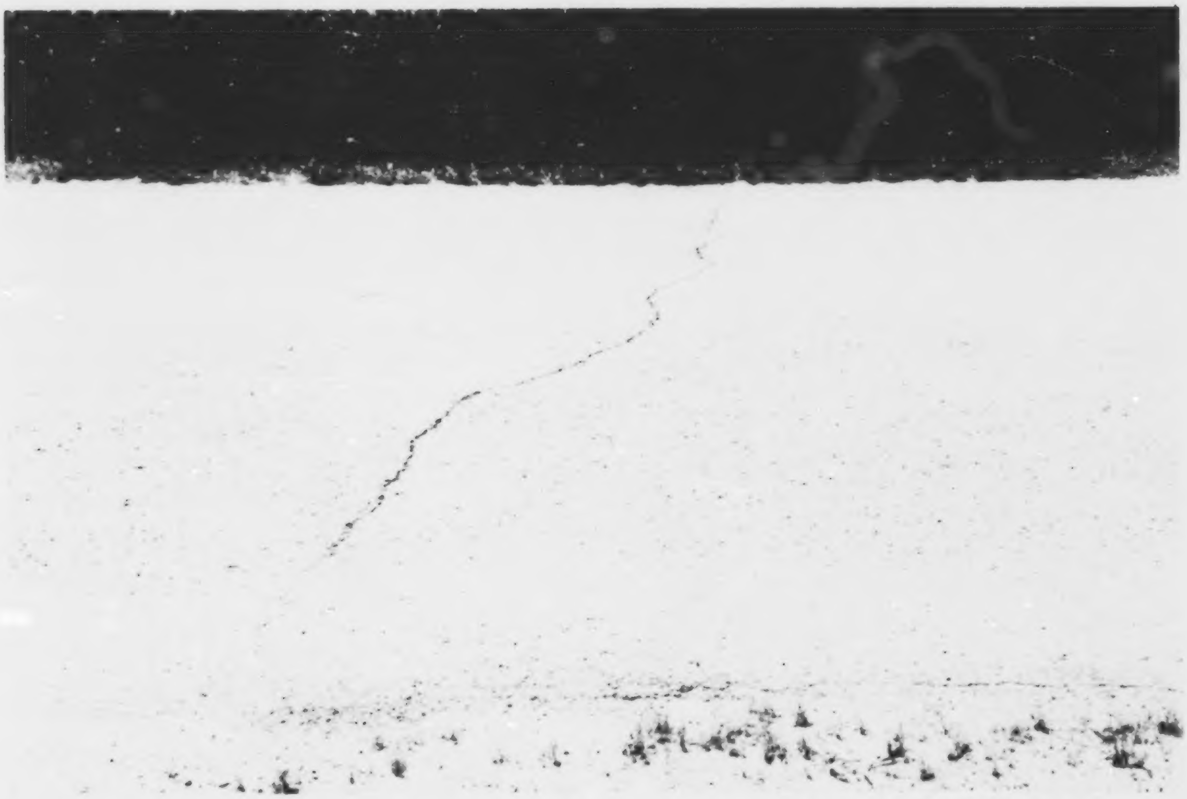
Severity:

Class	Guidelines
Slight	2 to 12 mm full and single.
Moderate	13 to 19 mm single, or multiple with cupping or lipping staining (even if crack opening is less than 13 mm).
Severe	20 mm plus single or multiple with cupping or lipping or spalling (even if crack opening is less than 20 mm).

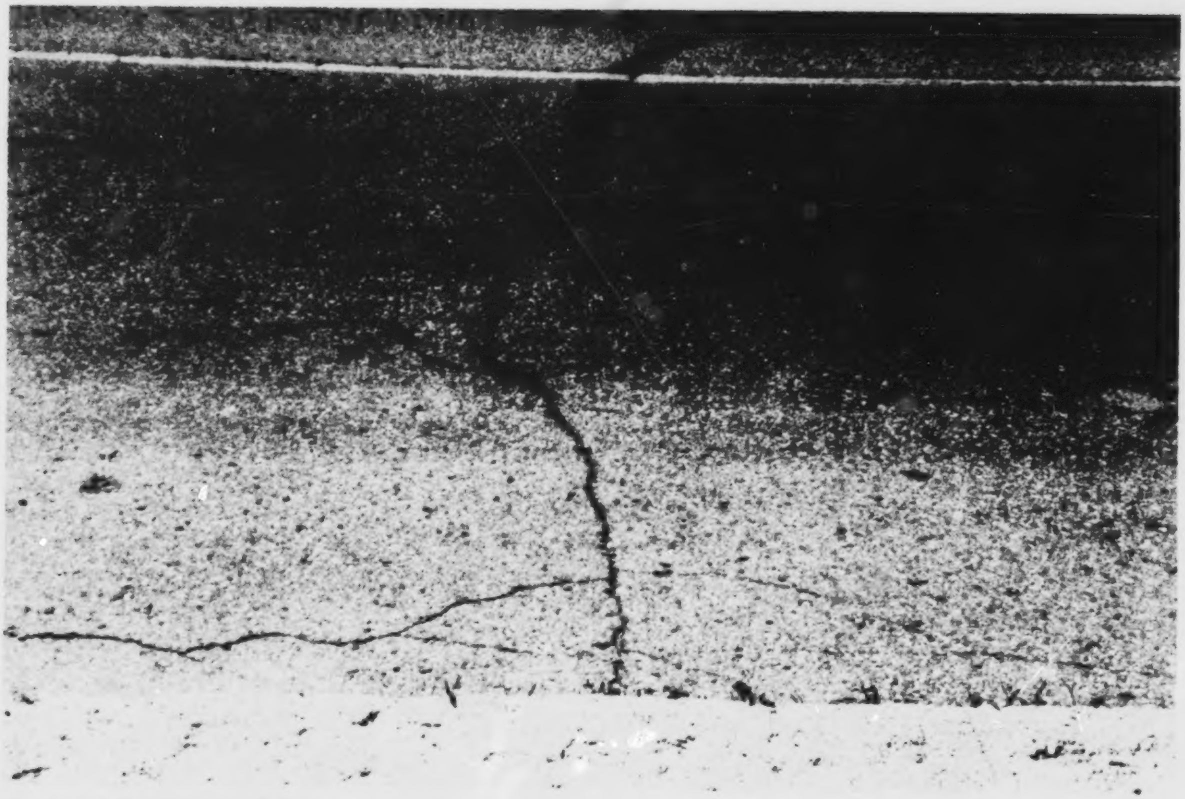
Density:

Intermittent	No set pattern, cracks 30 to 40 m apart, 20% or less of pavement surface affected, spotted evenly or localized.
Frequent	A set pattern, cracks 20 to 30 m apart, 21 to 50% of pavement surface affected, spotted evenly over length of pavement section.
Extensive	Regular pattern, cracks 10 to 20 m or less apart, greater than 50% of pavement surface affected, spotted evenly over length of pavement section.

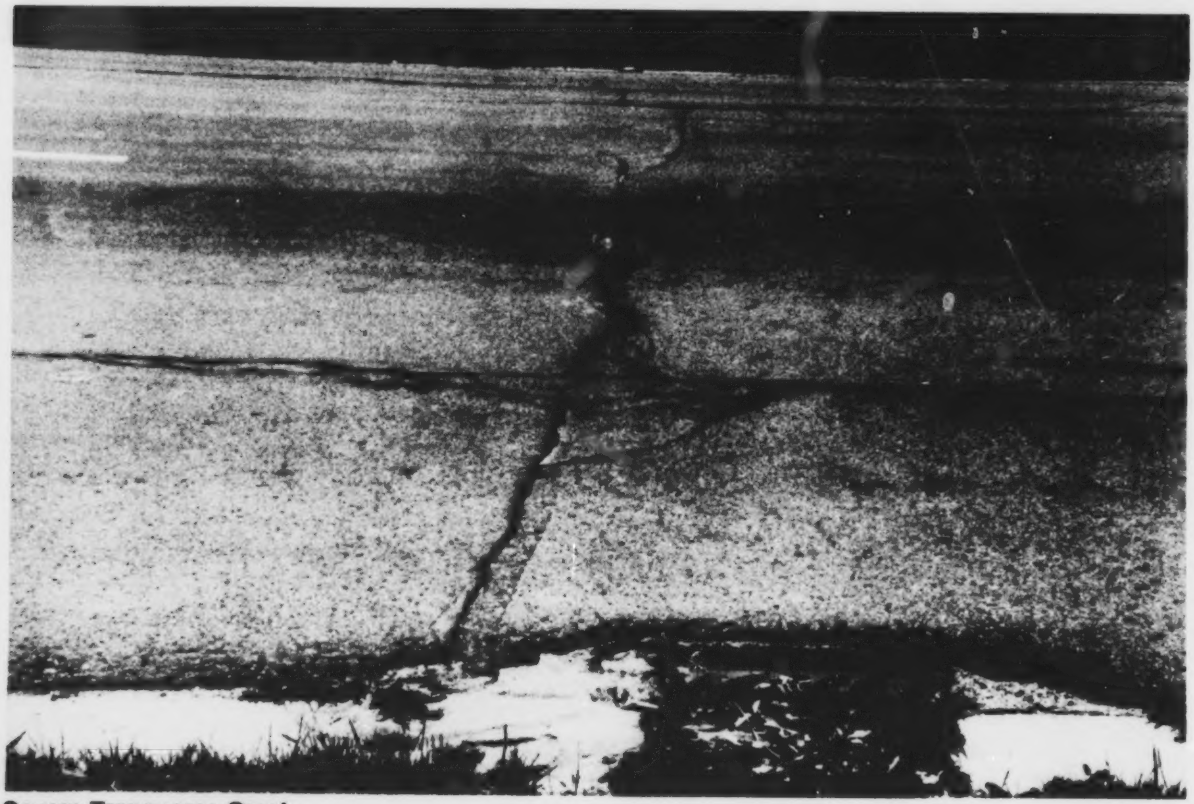
Slight Transverse Crack



Slight Transverse Crack



Moderate Transverse Crack



Severe Transverse Crack

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	- Rout and seal all cracks if pavement is composite type (asphalt over concrete) - Rout and seal if crack is >6 mm when pavement is asphalt only
	Frequent	- Same as above
	Extensive	- Same as above
Moderate	Intermittent	- Rout and seal if crack is single without multiple cracking or with only minor amount of multiple cracking
	Frequent	- Same as above
	Extensive	- Same as above - No action but place on Rehabilitation Program
Severe	Intermittent	- Rout and seal or just clean and seal if crack is single only and cupping or lipping not yet severe
	Frequent	- No action but place on Rehabilitation Program
	Extensive	- Rehabilitation Program

Pavement Edge Cracking

Description:

Crack is parallel to the pavement edge and is either a straight continuous crack or consists of crescent-shaped cracks in a wave formation. On thin asphalt surfaces in southern Ontario, pavement edge cracking can progressively encroach into the outer wheel tracks and through the middle of the pavement lane, and may even progress right across to the centreline.

Possible causes:

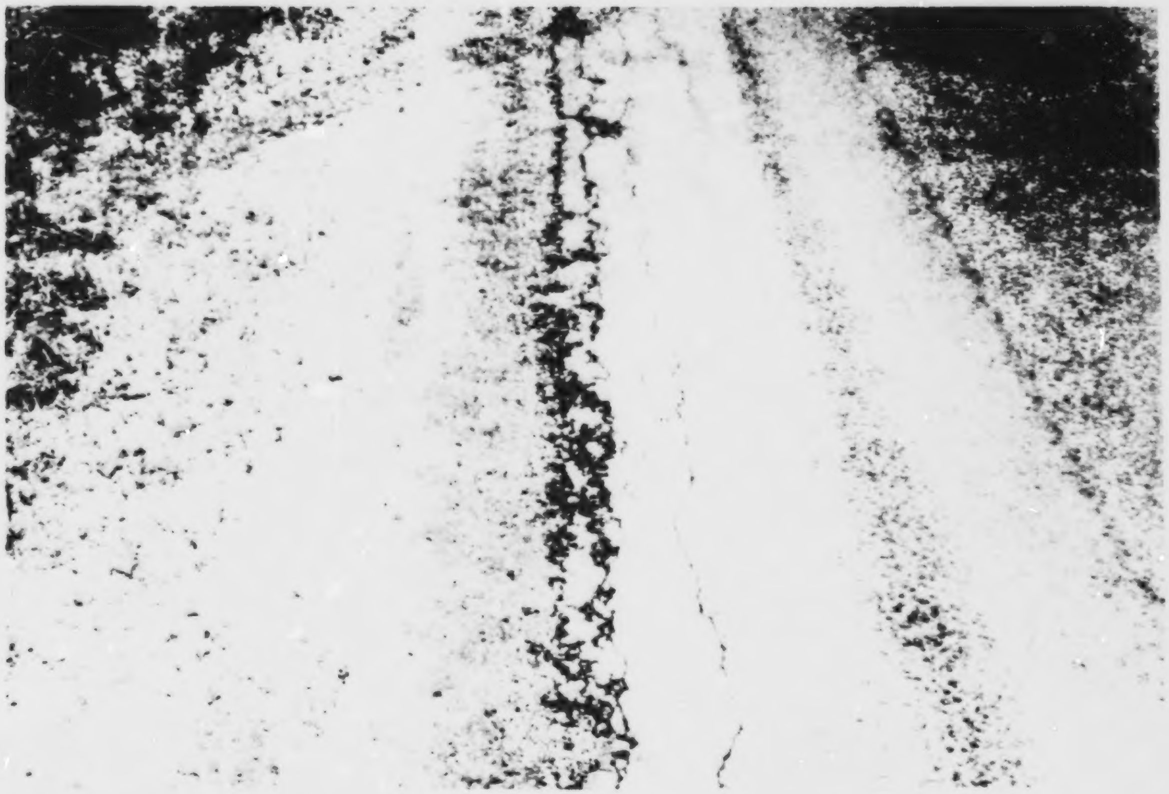
1. Frost action.
2. Insufficient bearing support and/or excessive traffic loading at the pavement edge.
3. Poor drainage at pavement edge and shoulder; in paved shoulder or gutter, joint is opened and unsealed against penetration of surface water.
4. Inadequate pavement width forces traffic too close to pavement edge.

Severity:

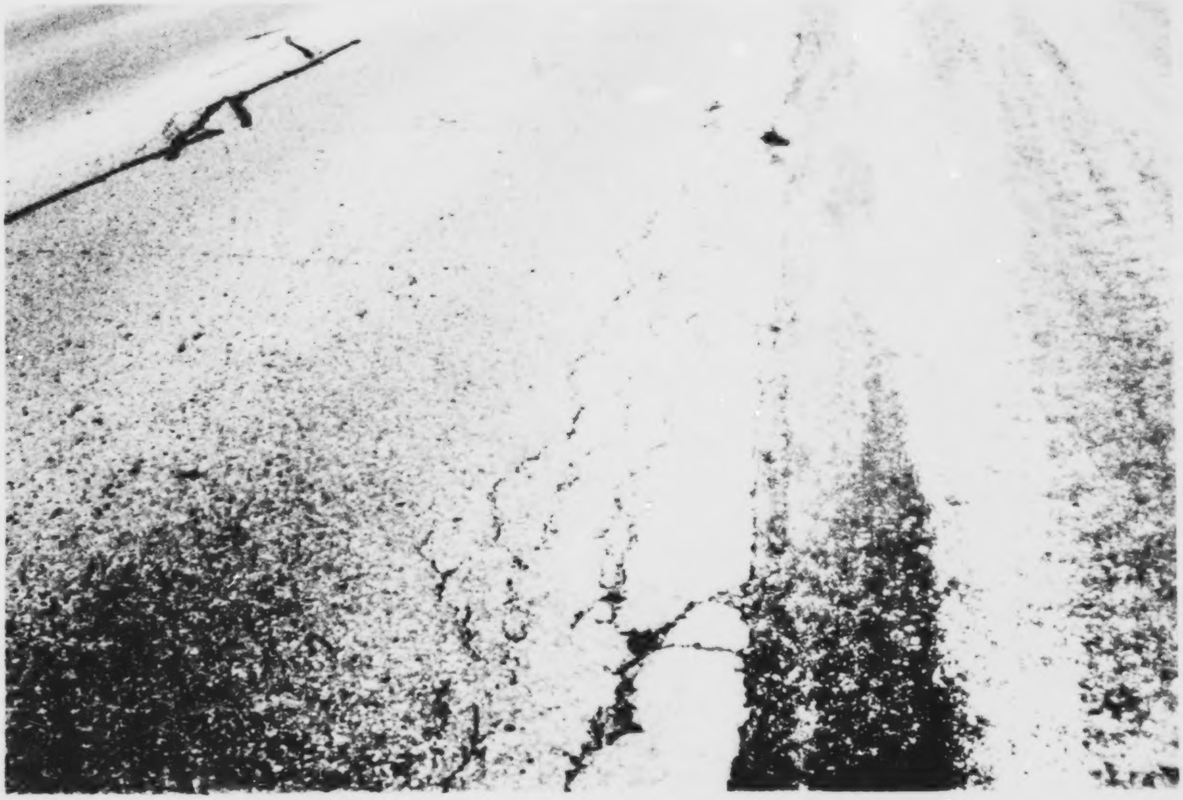
Class	Guidelines
Slight	Less than 300 mm from pavement edge; single crack or two parallel cracks.
Moderate	Extending over 300 mm but less than 600 mm from pavement edge, multiple cracks with connecting cracks.
Severe	Extending over 600 mm from pavement edge; alligatoring of pavement at and near pavement edge.

Density:

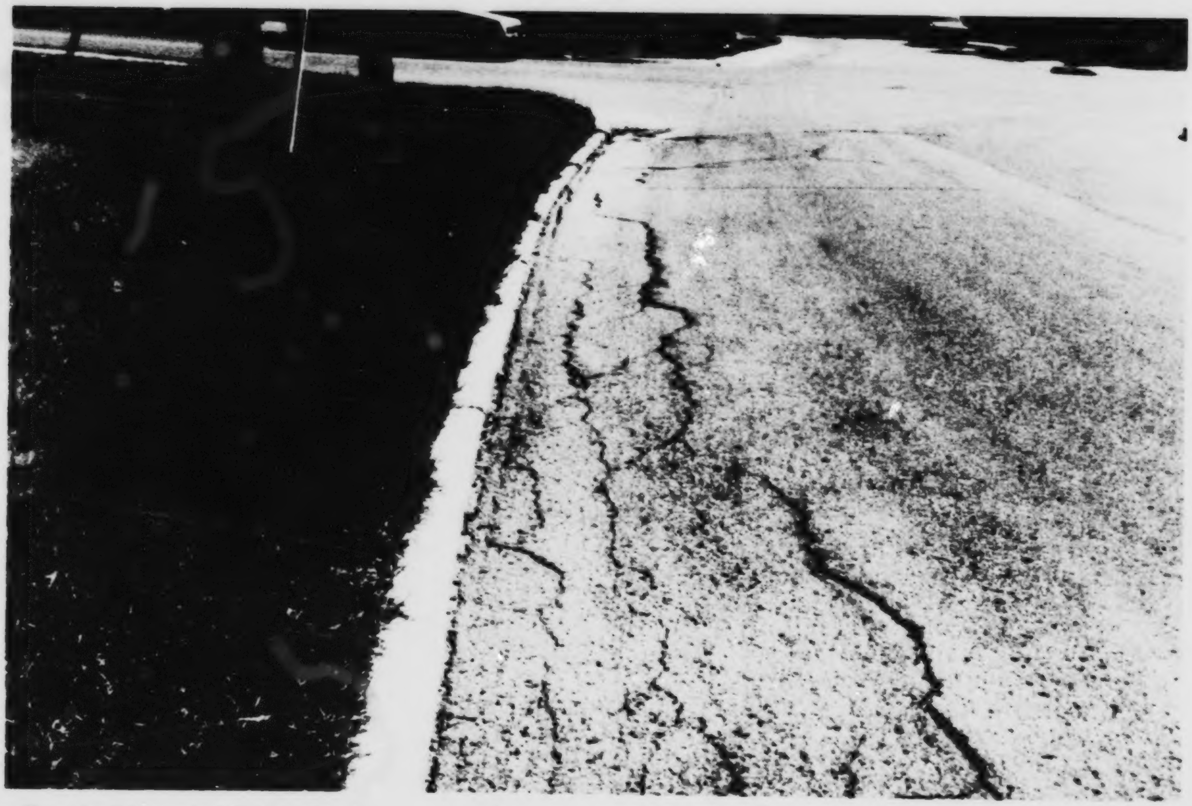
Intermittent	Less than 20% of the pavement edge affected; distress spotted in localized areas only.
Frequent	20 to 50% of the pavement edge affected; distress spotted in localized areas or evenly over pavement section length.
Extensive	Greater than 50% of the pavement edge affected; distress spotted evenly over pavement section length.



Slight Pavement Edge Crack



Moderate Pavement Edge Crack



Severe Pavement Edge Crack

Severe Pavement Edge Crack

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• No action
	Frequent	• No action
	Extensive	• Manual Chip Seal
Severe	Intermittent	• Manual Chip Seal
	Frequent	• Manual Chip Seal
	Extensive	• Machine Chip Seal • No action but place on Rehabilitation Program

Map Cracking

Description:

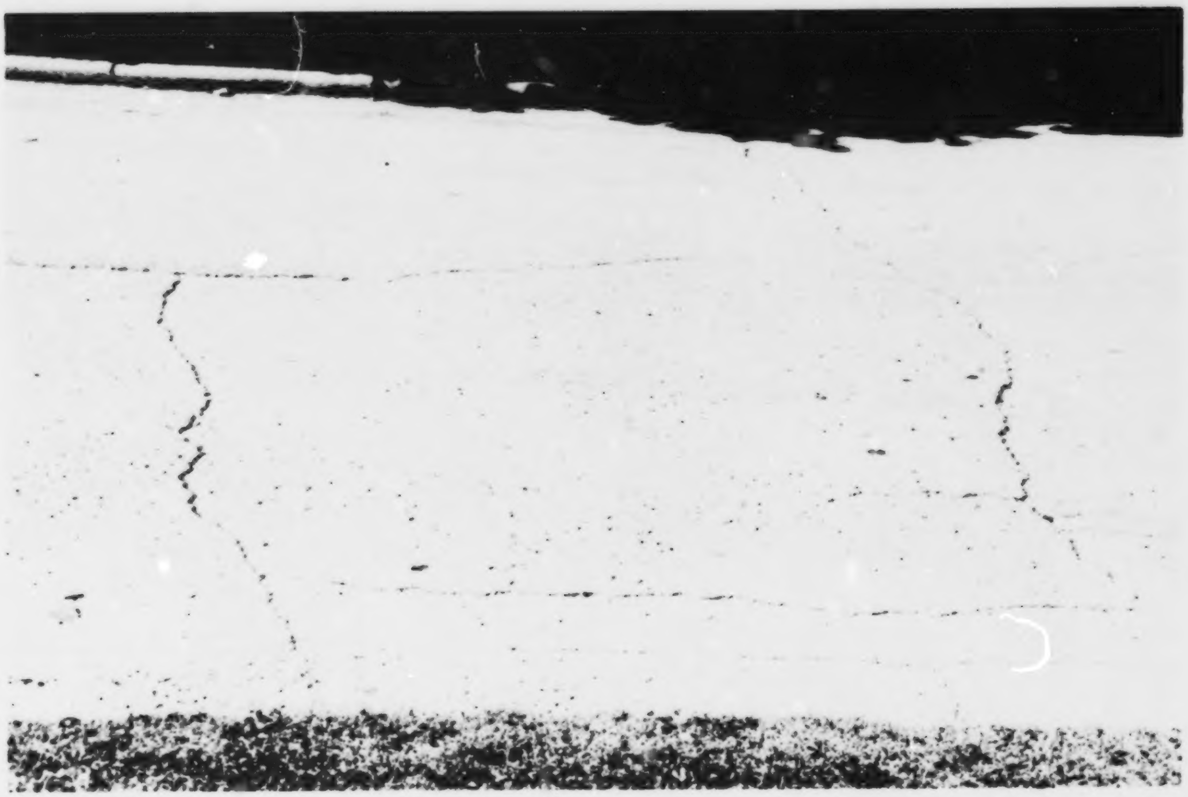
Interconnected cracks forming a series of large polygon blocks which look overall like a map. The cracking appears to combine transverse and longitudinial cracks together to form a map. This form of distress is also referred to as random cracking.

Possible causes:

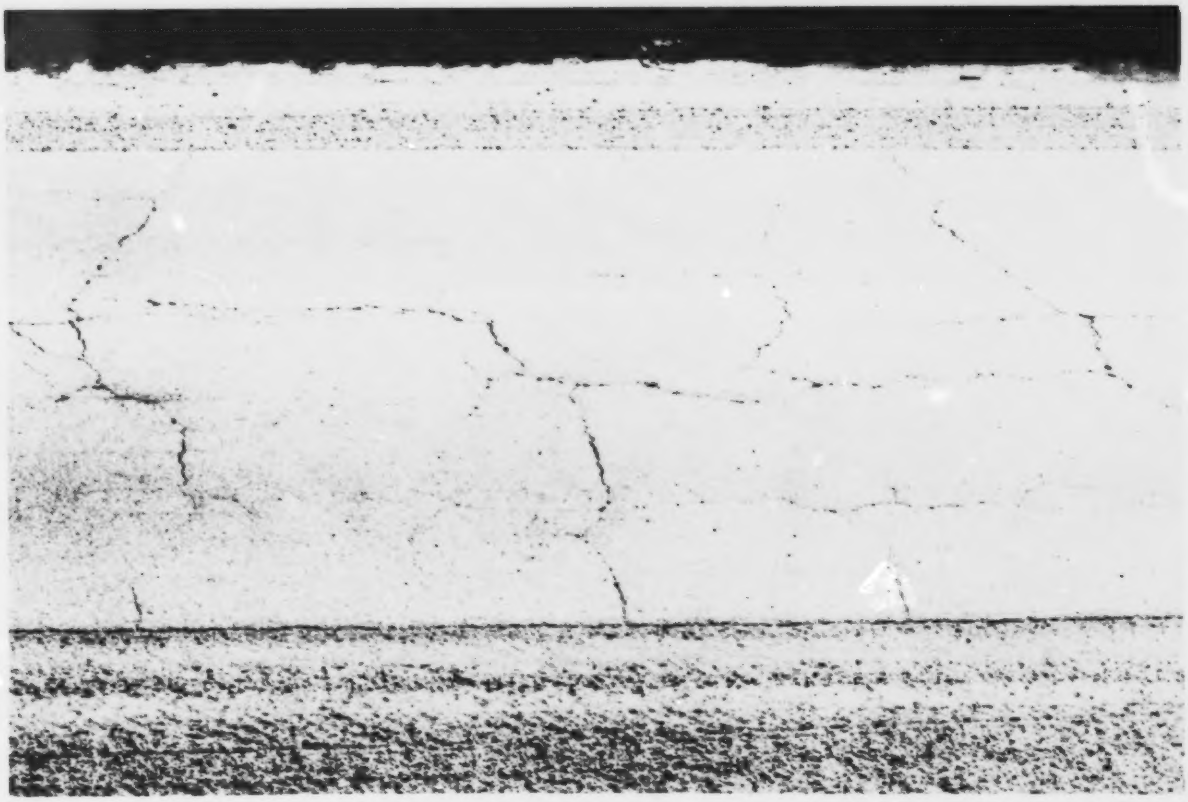
1. Swelling or shrinkage.
2. Frost action.
3. Hardening and shrinkage of the asphalt due to age.

Severity:	Class	Guidelines
	Slight	Single crack 2 to 12 mm well spaced but interconnected to form map.
	Moderate	Interconnected cracks begin to develop into multiple cracks, first sign of spalling; or single cracks 13 to 19 mm.
	Severe	Multiple interconnected cracks, some beginning to spall; or single cracks 20 mm plus.

Density:	Intermittent	Less than 20% of pavement surface affected; distress spotted in localized areas only.
	Frequent	20 to 50% of pavement surface affected; distress spotted evenly over the pavement section length or in localized areas only.
	Extensive	Greater than 50% of pavement surface affected; distress spotted evenly over the pavement section length.



Slight Map Crack



Moderate Map Crack

Severe Map Crack

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• No action
	Frequent	• No action
	Extensive	• Consider placing on Rehabilitation Program
Severe	Intermittent	• Machine Chip Seal • Machine Patching
	Frequent	• No action but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

Alligator Cracking

Description:

Cracks which form a network of multi-sided (polygon) blocks resembling the skin of an alligator. The block size can range from a few millimetres to about one metre. The block sizes are indicative of the level (depth) at which failure is taking place. The small block sizes, 100 to 150 mm, indicate that movement is occurring in the upper (granular base) layer. This type of alligatoring is mostly observed on "thin" (less than 75 mm) asphalt surfaces, accompanied at times by slight depressions (perhaps 12 mm). The large block sizes, 300 mm and more, indicate that movement is occurring in the deep granular layers and subgrade. This type of alligatoring is accompanied by large depressions (perhaps as much as 50 mm) together with a lateral movement outwards (and upwards) of the pavement edge: it forms a puddle during rains.

Alligator cracking is a consequence of the inability of a part of the structure to support the repeated loads due to a "softening" of the underlying material. "Softening" is normally associated with an increase in moisture content. Therefore, cracks such as transverse, centreline and longitudinal left unsealed will allow surface water to penetrate the pavement structure and cause "softening", with the end result of alligatoring as the final stage of crack development.

Alligator type failures which are deep-seated in the subbase or subgrade are progressive, i.e., under traffic and rains they tend to spread rapidly, and traffic causes blocks of surfacing to be displaced and broken up. The only successful remedial treatment is the removal of all softened material in the affected area and replacement with sound materials. Alligator failures which are in the upper layers normally appear in the very early spring. They do not generally progress after warmer weather first appears, probably because drainage of the wet granular bases has increased its strength.

Possible causes:

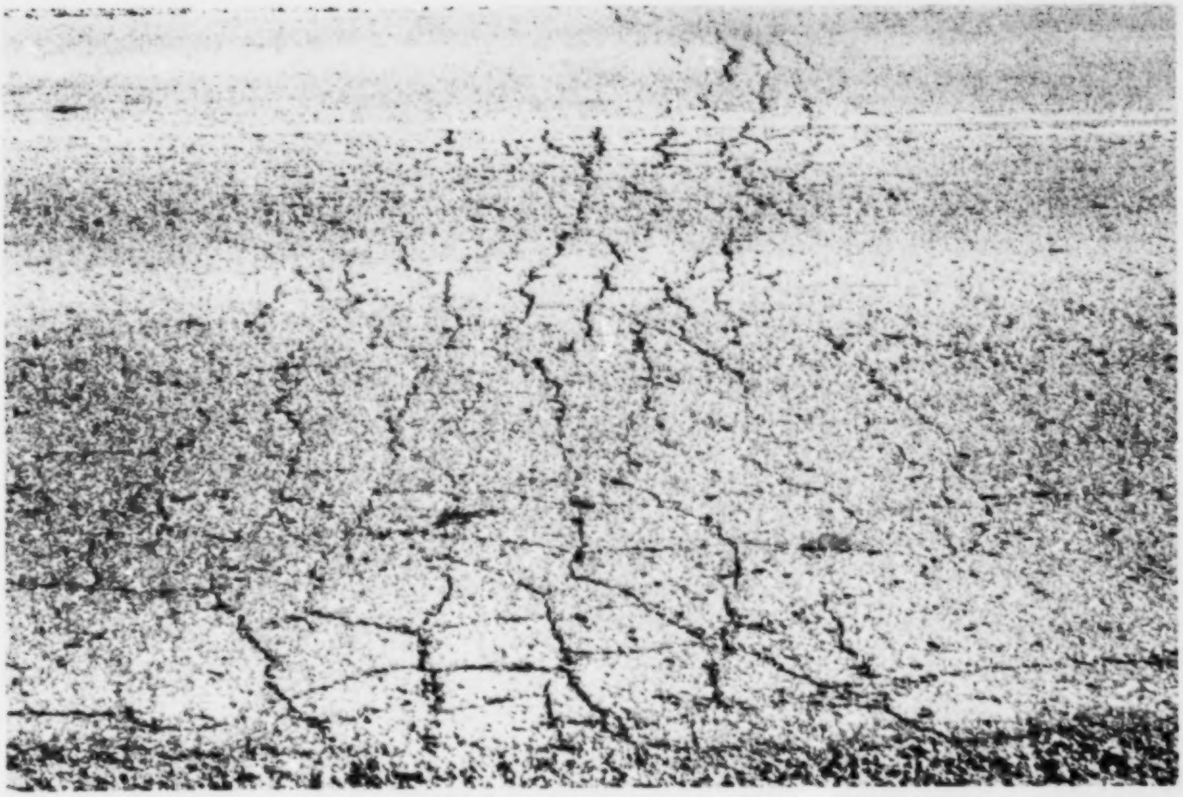
1. Insufficient bearing support.
2. Poor base drainage and stiff or brittle asphalt mixes at cold temperatures.

Severity:

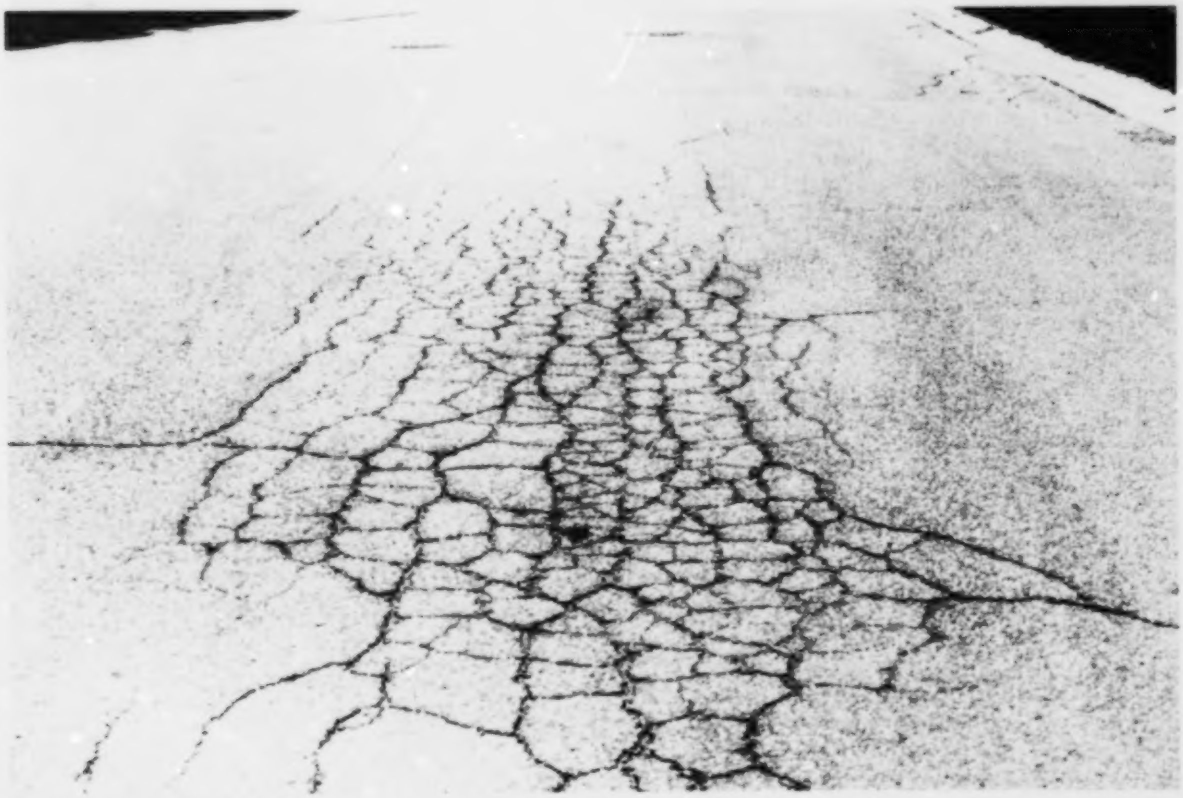
Class	Guidelines
Slight	Alligator pattern established with corners of polygon blocks fracturing. Distortion less than 13 mm.
Moderate	Alligator pattern established with spalling of polygon blocks. Distortion 13 to 25 mm.
Severe	Polygon blocks begin to lift; small potholes. Distortion greater than 25 mm.

Density:

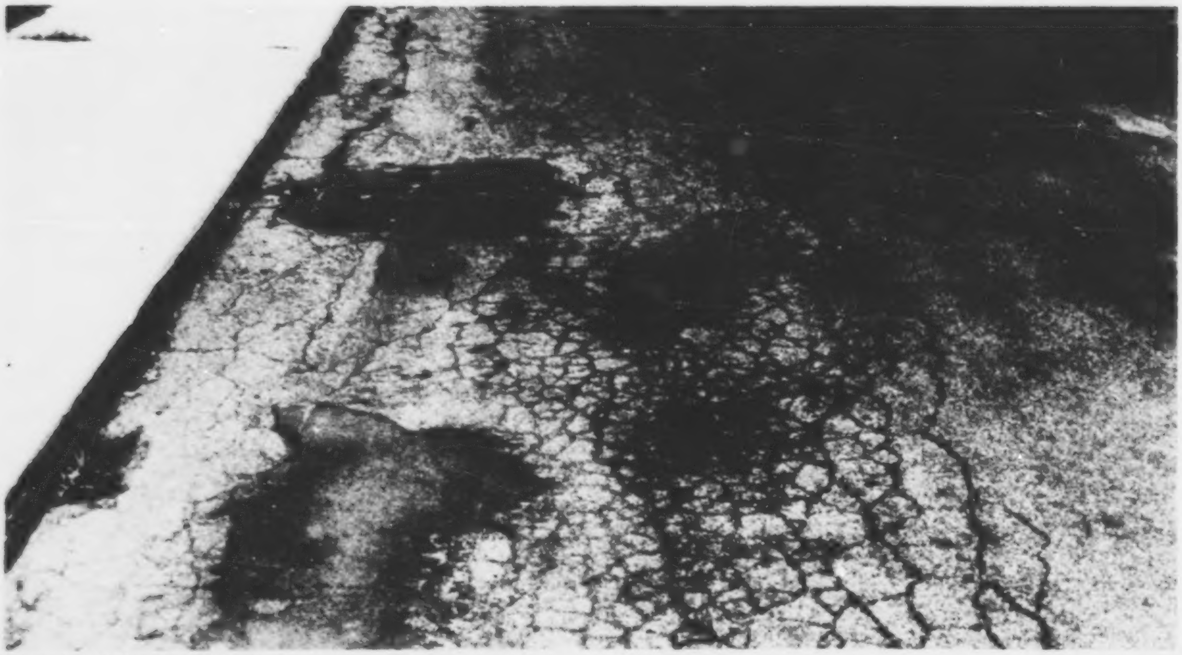
Intermittent	20% or less surface area of the pavement section affected; distress spotted in localized areas only.
Frequent	20 to 50% surface area of the pavement section affected; distress spotted evenly over the length of pavement section or in localized areas.
Extensive	Greater than 50% surface area of the pavement section affected; distress spotted evenly over pavement section length.



Slight Alligator Crack



Moderate Alligator Crack



Severe Alligator Crack

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• Manual Chip Seal
	Frequent	• Manual Chip Seal
	Extensive	• Machine Chip Seal • Machine Patching
Moderate	Intermittent	• Manual Patching • Machine Patching
	Frequent	• Manual Patching • Machine Patching
	Extensive	• Machine Patching and place on Rehabilitation Program
Severe	Intermittent	• Manual Patching • Machine Patching
	Frequent	• Manual Patching • Machine Patching • Patching and place on Rehabilitation Program
	Extensive	• Rehabilitation Program

6/ Paved Shoulder Distress Manifestations

- **Pavement Edge, Paved Shoulder (or Curb) Separation**
- **Paved Shoulder Cracking**
- **Paved Shoulder Breakup and Potholes**
- **Paved Shoulder Distortion**

Pavement Edge, Paved Shoulder (or Curb) Separation

Description:

The longitudinal joint between the pavement lane and the paved shoulder (or curb/gutter) is opened or separated.

Possible causes:

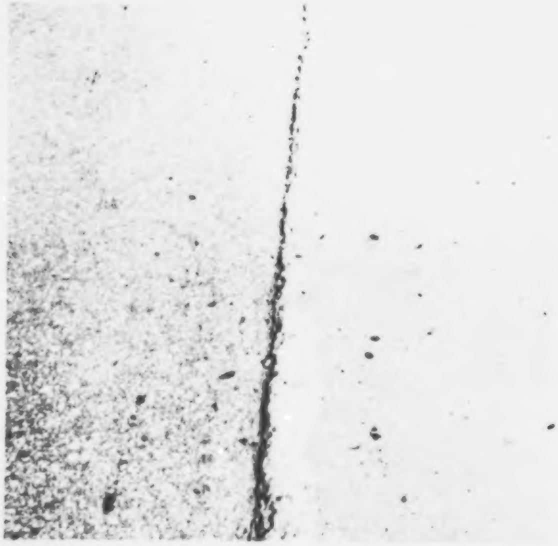
1. Movement due to differential frost action and settlement.
2. Contraction of asphalt pavement in low temperatures is not fully recovered when pavement warms up, resulting in a gap between curb/gutter and pavement surface which grows wider year after year.
3. Failure of sealant material used in the longitudinal joint of pavement lane and paved shoulder or curb and gutter.
4. Cracking.

Severity:

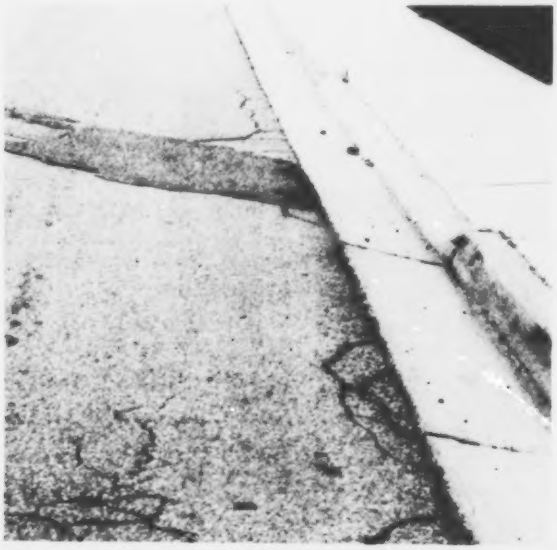
Class	Guidelines
Slight	Less than 13 mm opening with or without single cracking.
Moderate	13 to 19 mm opening with or without multiple cracking.
Severe	Greater than 19 mm opening with or without multiple cracking.

Density:

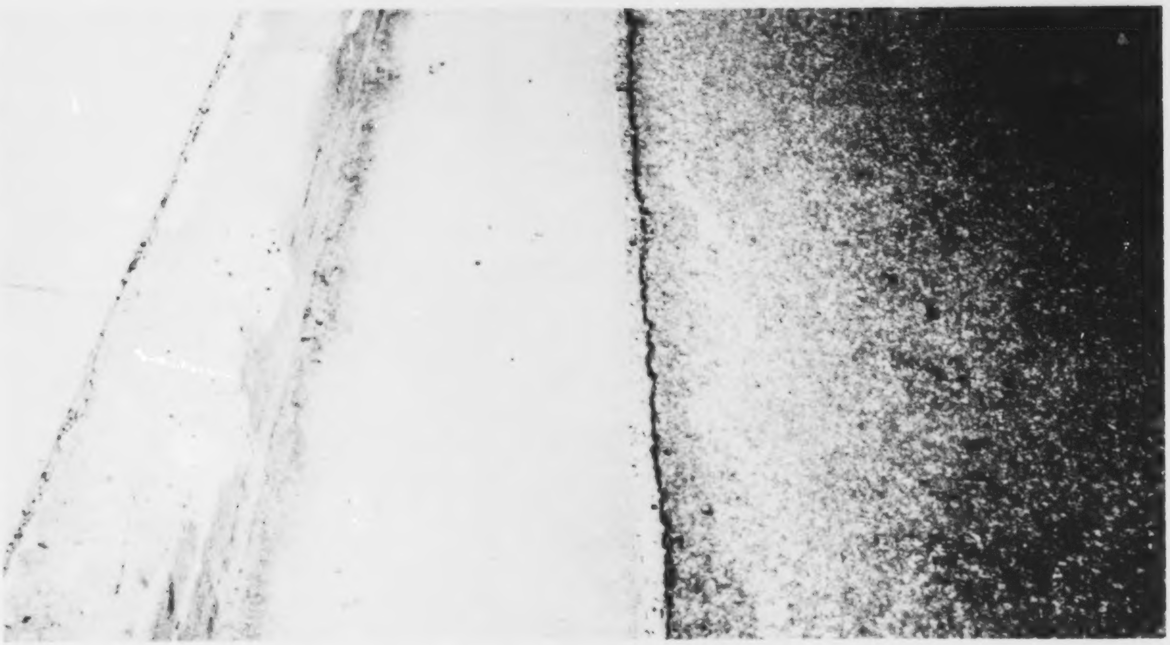
Intermittent	Less than 20% of pavement surface affected; distress spotted in localized areas only.
Frequent	20 to 50% of pavement surface affected; distress spotted evenly over length of pavement or in localized areas.
Extensive	Greater than 50% of pavement surface affected; distress spotted evenly over length or pavement.



Slight Pavement Edge and Curb Separation



Moderate Pavement Edge and Curb Separation



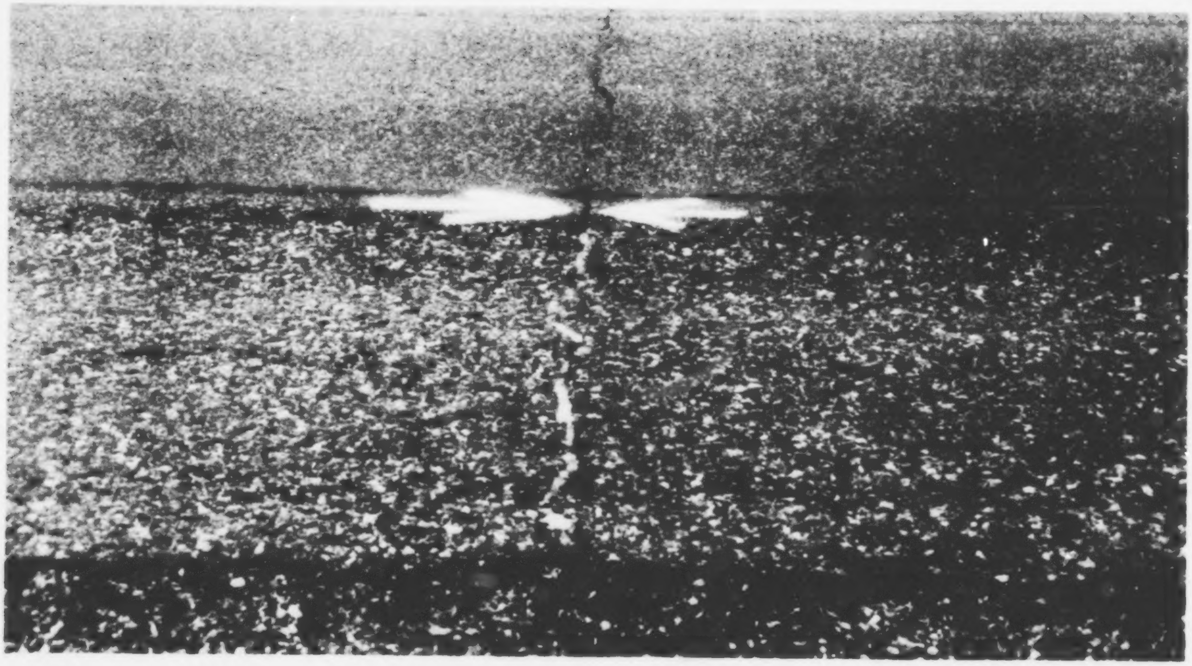
Severe Pavement Edge and Curb Separation

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent Frequent Extensive	• No action • Rout and seal • Rout and seal
Moderate	Intermittent	• Rout and seal • Clean and seal
	Frequent	• Rout and seal • Clean and seal
	Extensive	• Rout and seal • Clean and seal
Severe	Intermittent	• Rout and seal • Clean and seal
	Frequent	• Rout and seal • Clean and seal
	Extensive	• Rout and seal • Clean and seal

Paved Shoulder Cracking

Description:	Cracking distresses occur in stabilized or paved shoulders in the same way as in pavement of similar type. Therefore, the same descriptions are applicable.
Possible causes:	1. Differential frost action 2. Settlement 3. Traffic loads
Severity:	See descriptions for various cracking distresses.
Density:	See descriptions for various cracking distresses.
Treatments:	See recommended maintenance treatment alternatives for various cracking distresses.



Slight Transverse Crack on Stabilized Shoulder

Paved Shoulder Breakup and Potholes

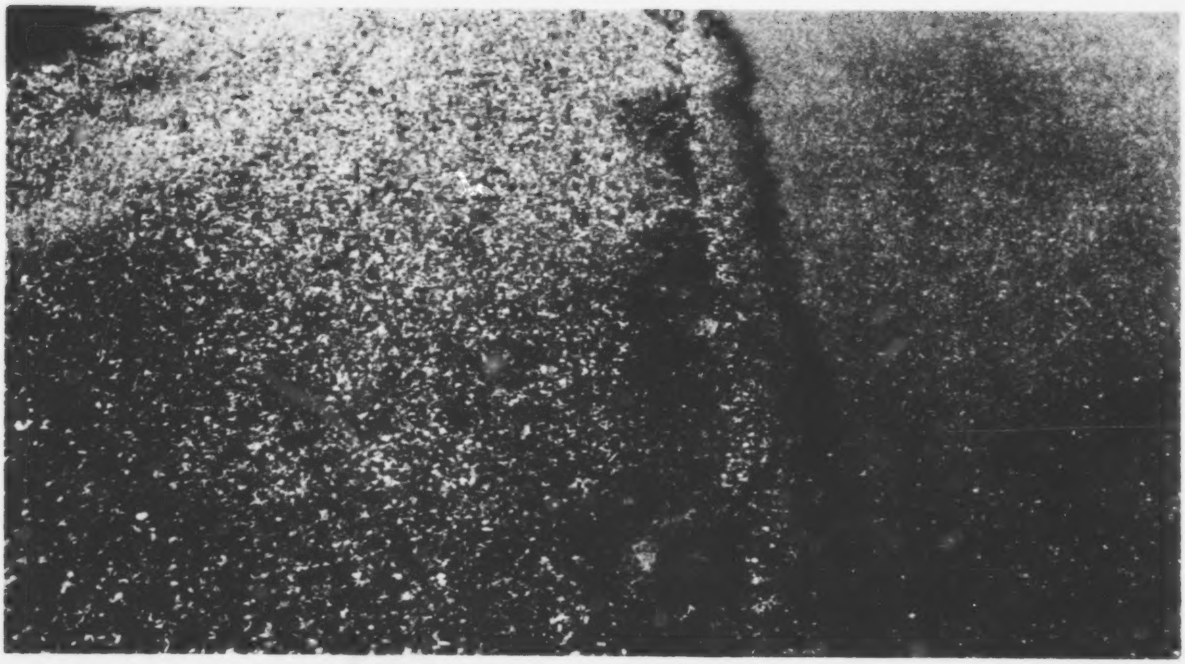
Description: These distresses occur in stabilized or paved shoulders in the same way as in pavements of similar type. Therefore, the same descriptions are applicable.

Possible causes: See descriptions for Potholes and Pavement Edge Break.

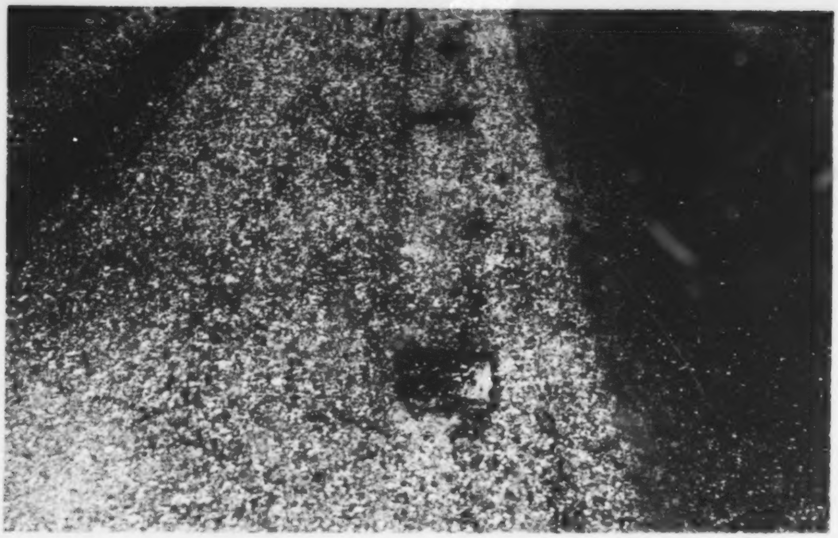
Severity: See descriptions for Potholes and Pavement Edge Break.

Density: See descriptions for Potholes and Pavement Edge Break.

Treatments: See descriptions for Potholes and Pavement Edge Break.

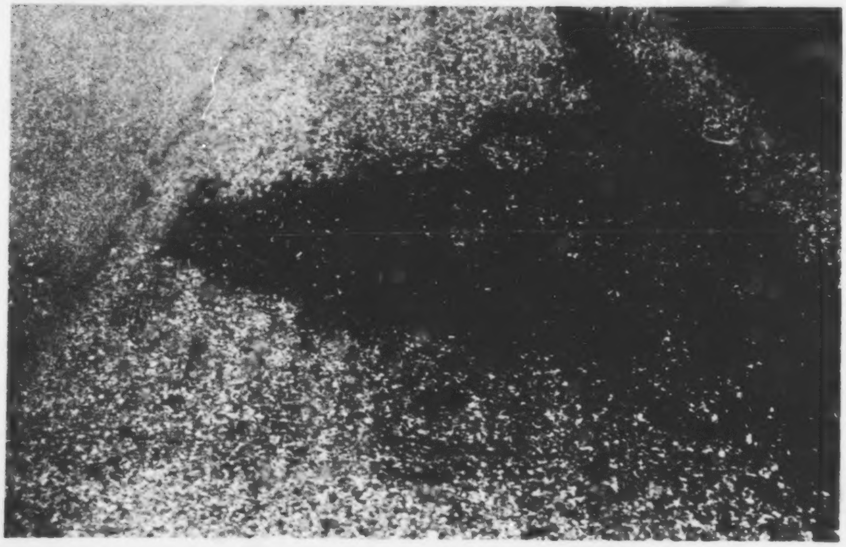


Edge Breakup of Stabilized Shoulder



Pothole on Stabilized Shoulder

Breakup of Stabilized Shoulder



Breakup of Stabilized Shoulder

Paved Shoulder Distortion

Description:

Any deviation of the surface from its original shape. Generally, these distortions result from settlement, volume changes due to moisture and frost heaving, residual effects of frost heaving accumulating after each winter.

Possible causes:

1. Differential frost action between pavement lane and paved shoulder or curb.
2. Differential settlement of subgrade or materials between pavement lane and paved shoulder or curb.
3. Traffic loading.

Severity:

See descriptions for various distortion distresses.

Density:

See descriptions for various distortion distresses.

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Slight	Intermittent	• No action
	Frequent	• No action
	Extensive	• No action
Moderate	Intermittent	• Manual Patching
	Frequent	• Manual Patching
	Extensive	• No action but consider placing on Rehabilitation Program
Severe	Intermittent	• Manual Patching
	Frequent	• No action but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

7/ Maintenance Treatment Alternatives

Treatment Alternatives

Manual Patching

Machine Patching

Cold Milling or Hot Planing with Manual Patching

Cold Milling or Hot Planing with Machine Patching

Manual Spray Patching

Manual Chip Seal

Machine Chip Seal

Fog Seal

Surface Treatment

Manual Burn and Seal

Crack Rout and Seal

Treatment Alternatives

Description:

When pavement distress leads to a rough surface condition, or to a locally dangerous bump or hole, maintenance is undertaken to:

- seal the surface to prevent water from penetrating the susceptible layers;
- smoothen the roughened surface; or
- cure the cause of the bump or hole [6,7].

Maintenance is undertaken also as a long-term preventive measure to:

- seal the surface to prevent water from penetrating the susceptible layers;
- strengthen the structurally inadequate section(s); or
- provide additional drainage facilities to remove any excess moisture from the structure [8].

A number of maintenance treatment alternatives are listed and illustrated. These treatments are matched against each distress manifestation for possible maintenance action under the same format as outlined in the Ministry's *Pavement Maintenance Guidelines–Distress, Maintenance Alternatives and Performance Standards* Report SP–001. [6]

This set of "Guidelines" is recommended as a handy reference because it offers the same array of maintenance treatments for possible maintenance action, plus the estimated "Expected Effective-Life" of each listed maintenance treatment, and the methodology of choosing the most cost-effective maintenance treatment for each particualr distress manifestation.

It is cautioned, however, that the suggestion given as the matching maintenance treatment vs. distress manifestation is not necessarily the most effective, and they may not effectively correct the cause or causes of the distress. The suggested treatment may only be an expedient measure to slow the distress deterioration.

On the other hand, these maintenance treatments are state-of-the-art and represent the best possible remedial measures given the availability of equipment and materials in the market place.

Patching will cover and hide pavement distress. However, condition reports on the extent and type of patching, when reviewed over a period, will tend to indicate whether the pavement deficiency is structural inadequacy or is due to faulty materials or otherwise.

In reporting on the presence of patches, the density of occurrence should be estimated in the terms given in the standard Density table. Similarly, in reporting on the presence of sealed cracks, the density of occurrence should be estimated in the terms given in the standard Density table for evaluating cracking.

Manual Patching

Description:

The manual placing and spreading of premixed asphaltic materials (hot, cold, or recycled mix) to repair potholes, bumps and depressions and other pavement distresses. Includes preparation of patching area and compaction with or without mechanical aids.

Manual Patching with Recycled Hot-Mix Asphalt

Manual Patching with Hot-Mix Asphalt

Machine Patching

Description:

The machine placing and spreading of premixed asphaltic materials (hot, cold mix) to repair major surface distresses such as alligator cracking, wheel track rutting, distortion, etc. Includes preparation of patching area and compaction with mechanical compactor(s).

Machine Patching with Hot-Mix Asphalt

Cold Milling or Hot Planing with Manual Patching

Description:

The machine removal of pavement surface defects such as distortion, followed by manual patching of milled areas with hot, cold or recycled asphaltic mix, including preparation of patching area and compaction with mechanical compactor(s).

Cold Milling for Manual Patching

Manual Patching with Hot-Mix Asphalt of Cold-Milled Surface

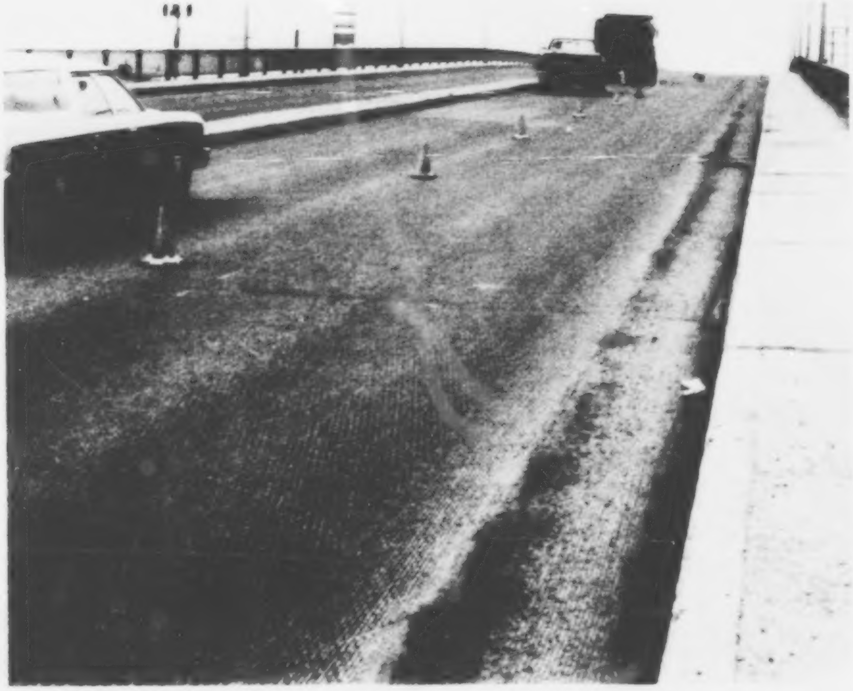
Cold Milling or Hot Planing with Machine Patching

Description:

The machine removal of pavement surface defects such as distortion, crack cupping and lipping, etc. followed by mechanical patching of milled surface with hot or recycled asphaltic mix, including preparation of patching area and compaction with mechanical compactor(s).

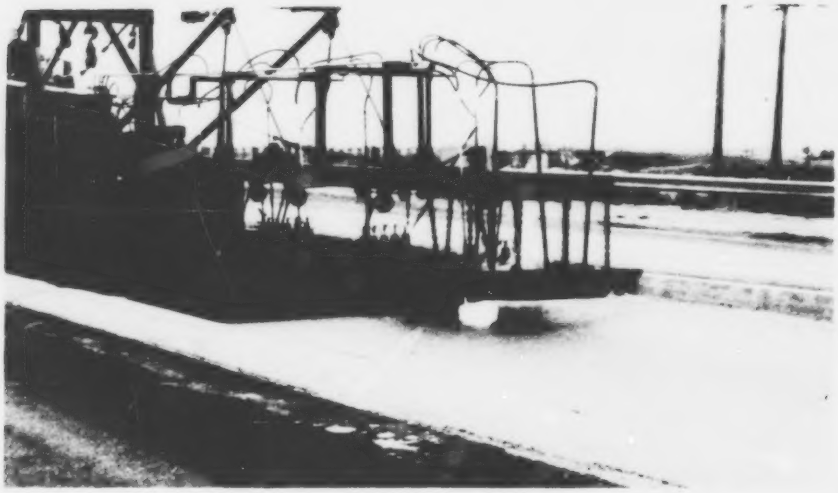
Cold Milling for Machine Patching

Cold-Milled Surface
for Machine Patching

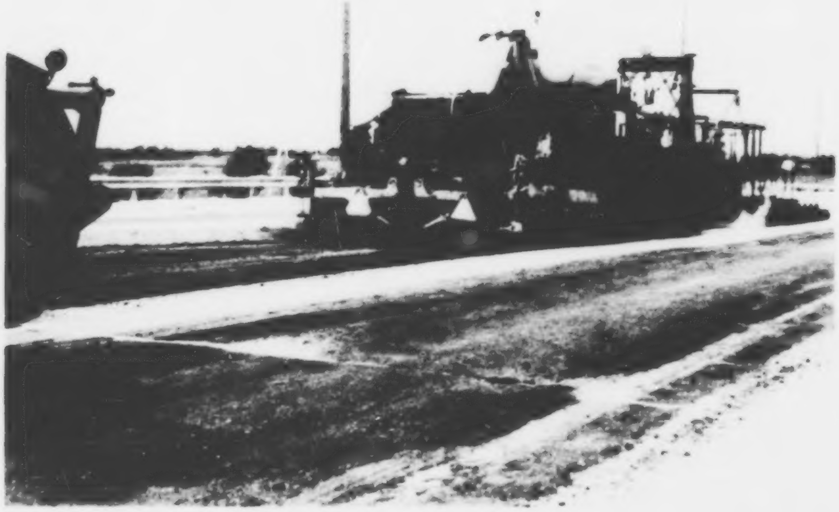


Machine Patching with
Hot-Mix Asphalt of
Cold-Milled Surface

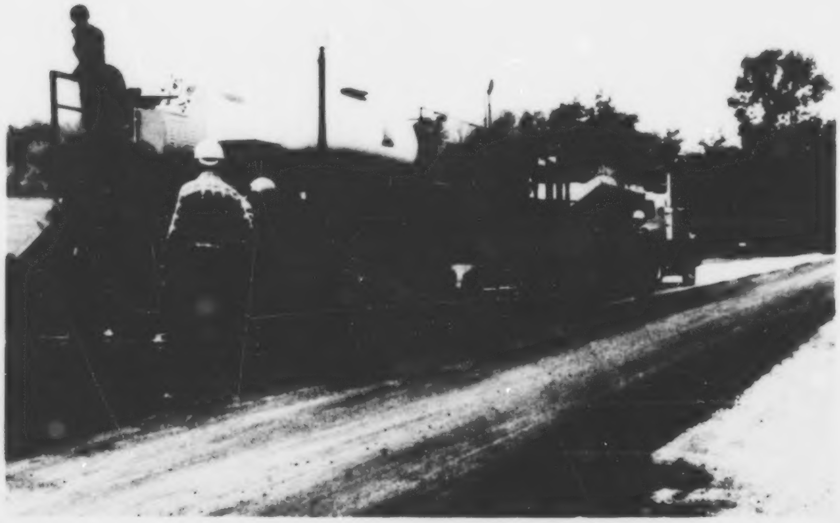
Hot Planing for Machine Patching



Machine Patching of Hot-Planed Surface



Hot Planing for Machine Patching with Recycling of Existing Pavement and New Hot-Mix Asphaltic Materials



Manual Spray Patching

Description: The manual application of emulsified asphalt to localized areas of pavement distresses, followed by spreading of aggregate (stone chip or sand) by hand.

Manual Spray Patching

Manual Chip Seal

Description:

The manual application of emulsified asphalt with a Mini Spray Bar to localized areas of pavement distresses, followed by spreading of selected aggregate (washed stone chips) with a chip spreader and compacted with a mechanical compactor.

Manual Chip Seal with Mini Spray Bar and Chip Spreader

Rolling of Stone Chip as Standard Work Procedure

Manual Chip Seal Treatment

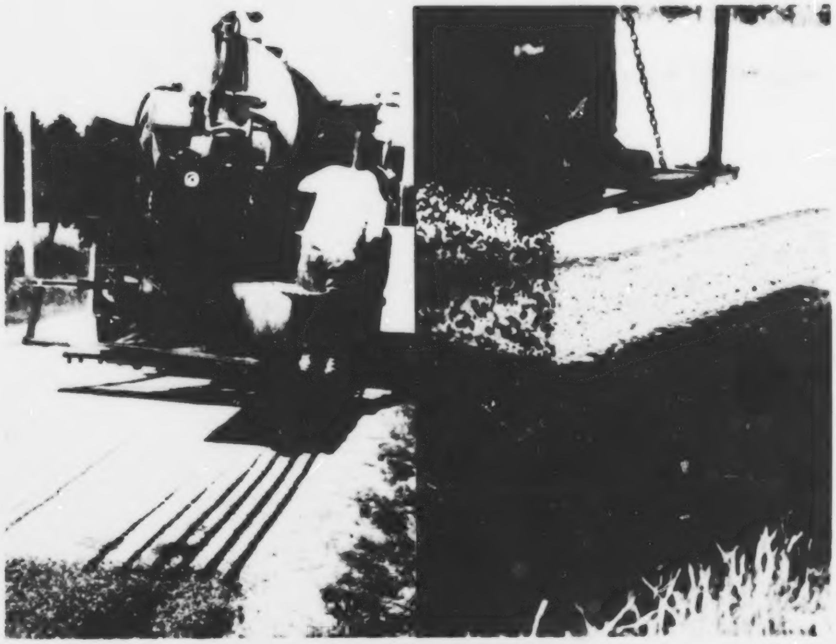
Machine Chip Seal

Description:

The machine application of emulsified asphalt to localized areas of pavement distresses, followed by machine spreading of selected aggregate and compacted with mechanical compactor(s).

Machine Chip Seal

Machine Chip Sealed Pavement



Machine Chip Seal Operation

Fog Seal

Description:

The machine application of slow-setting asphalt emulsion diluted with water to renew asphalt surfaces and to seal small cracks and surface voids, etc, followed by machine spreading of sand or usually without as a standard practice.

Fog Sealing

Surface Treatment

Description:

The machine application of emulsified asphalt to continuous sections of road surface, followed by spreading of aggregate with a mechanical spreader, and compaction by mechanical compactors.

Surface-Treatment Equipment Train

Surface-Treatment Spraying Emulsion

Spreading Stone Chips

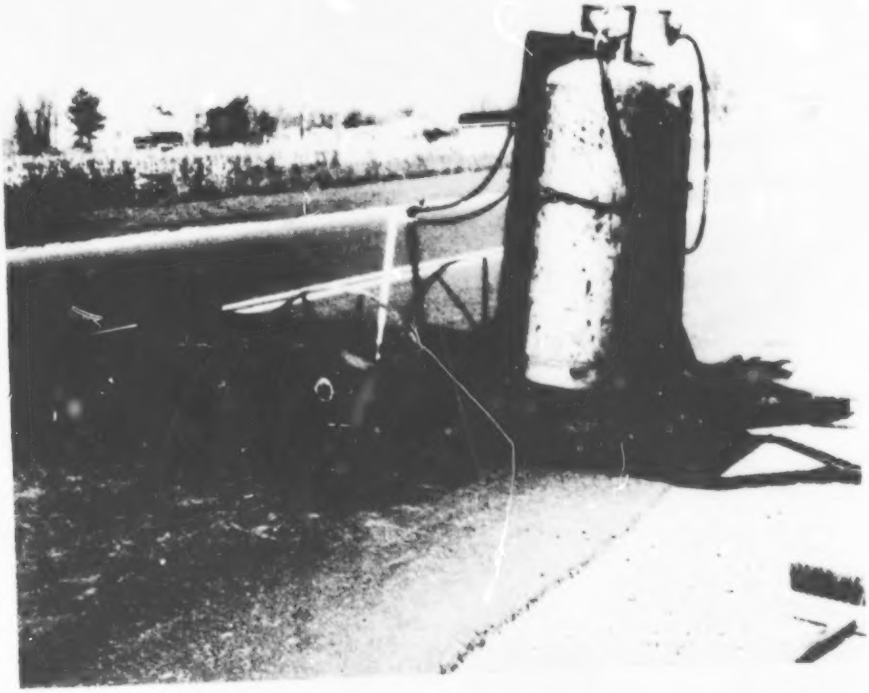
Rolling of Finished Surface Treatment

Manual Burn and Seal

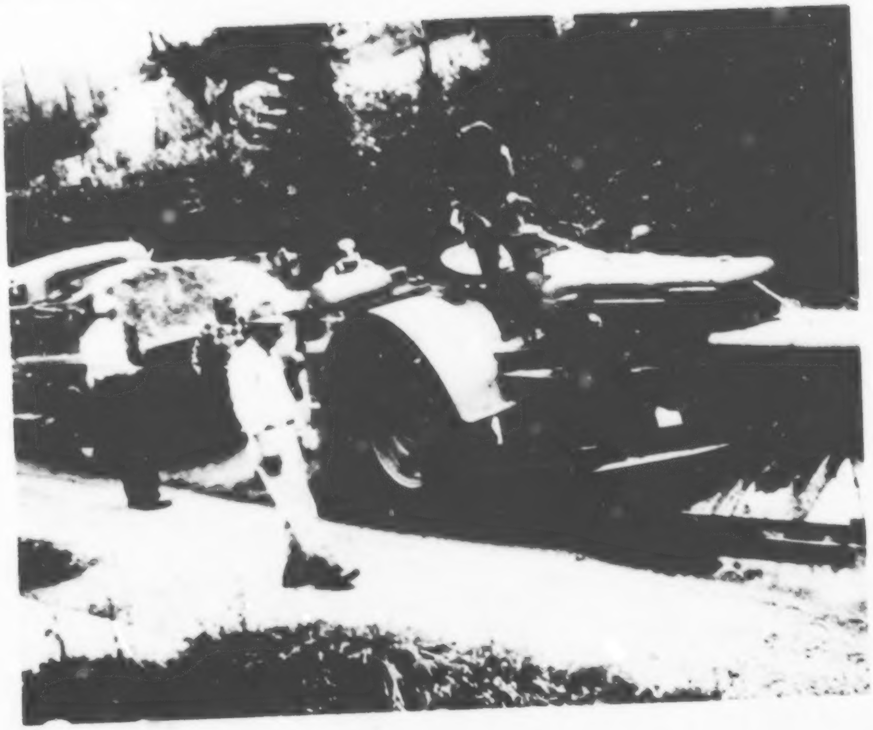
Description:

The elminination of excess surface asphalt by open flame burning unit and sealed with heated aggregate or manual chip seal.

Asphalt Pavement Burner



Burn and Seal Operation

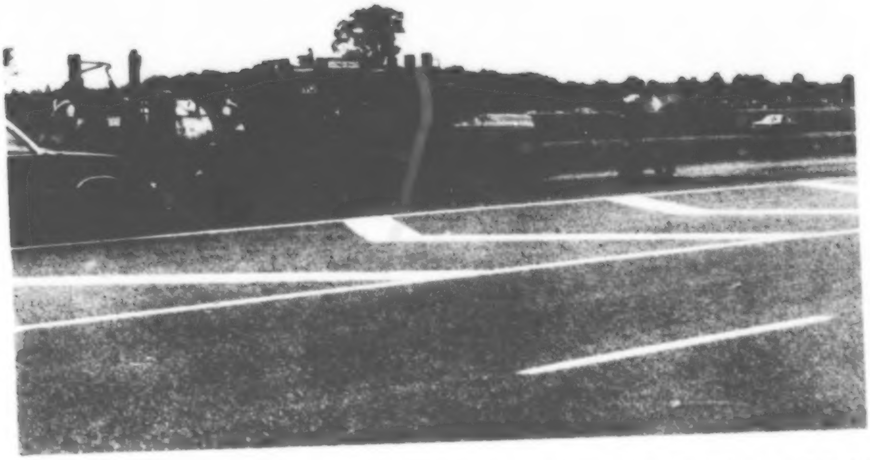


Crack Rout and Seal

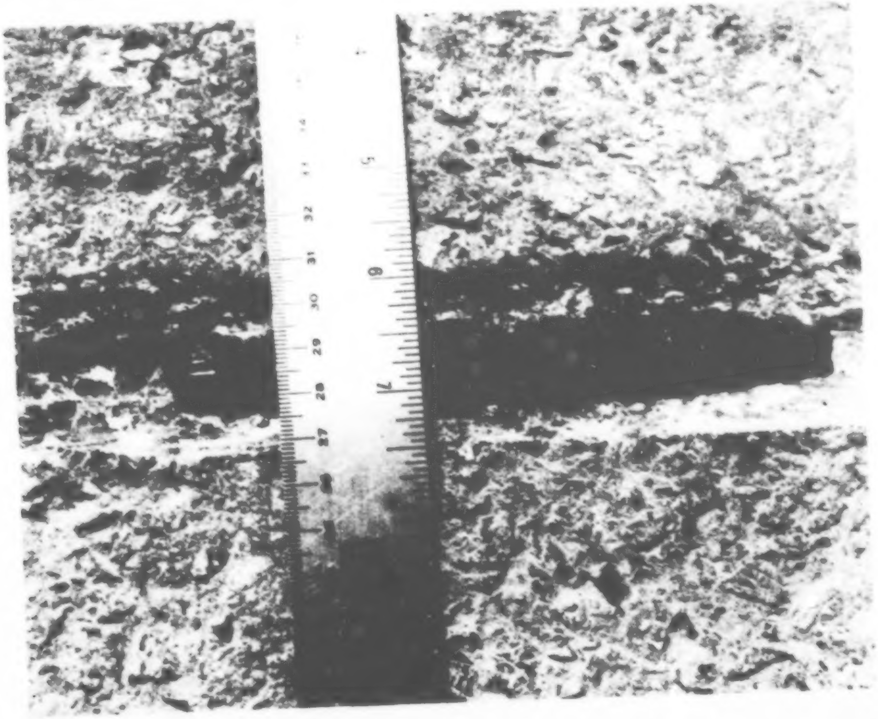
Description:

The machine routing, heated compressed air cleaning and drying of the routed crack, and sealing with polymerized asphalt sealant of cracking distresses.

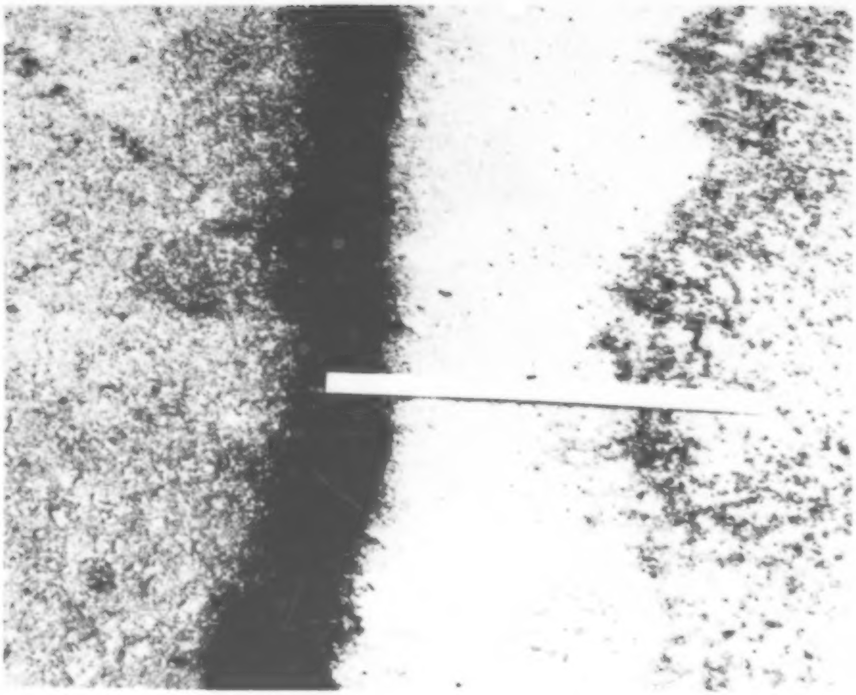
Rout and Seal Operation



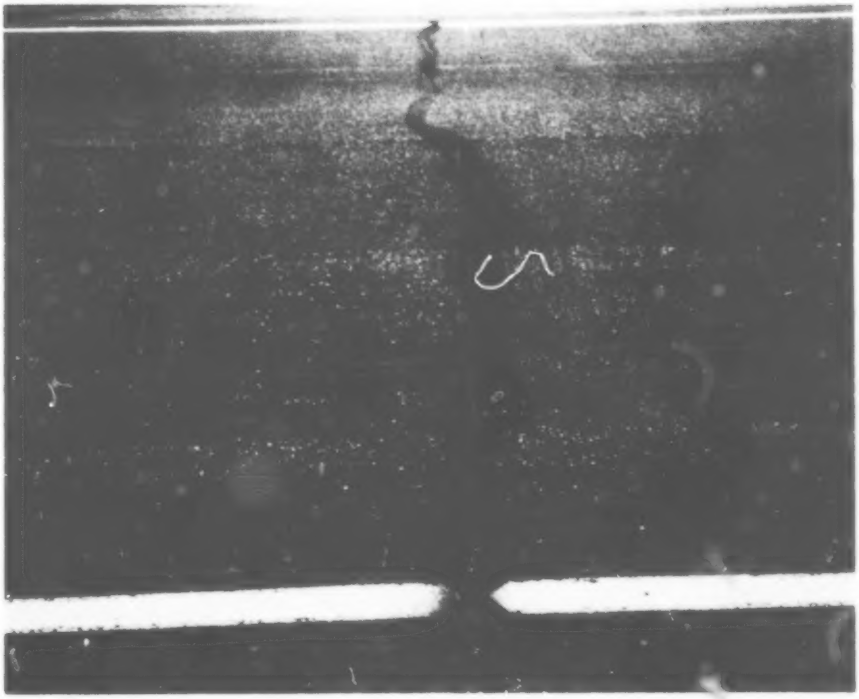
Routed Crack



Dry and Clean with Heat Lance



Sealed with Hot-Pour Polymerized Asphalt



References

[1] **Chong, G.J., Phang, W.A., Wrong, G.A.,** *Manual for Condition Rating of Flexible Pavements — Distress Manifestations*, Report SP-004 (revised SP-024, 1989), Ministry of Transportation and Communications, Ontario, Canada, 1975. Presented at the Transportation Research Board, Washington, D.C., 1976.

[2] **Chong, G.J., Phang, W.A., Wrong, G.A.,** *Manual for Condition Rating of Rigid Pavements — Distress Manifestations*, Report SP-005, Ministry of Transportation and Communications, Ontario, Canada, 1977.

[3] **Phang, W.A., Chong, G.J.,** "Ontario Flexible Pavement Distress Assessment for use in Pavement Management," Report PAV-81-01, Ministry of Transportation and Communications, Ontario, Canada, 1981. Presented at the Transportation Research Board, Washington, D.C., 1982. Also presented at the Canadian Technical Asphalt Association Conference, Edmonton, Alberta, November, 1982.

[4] **Phang, W.A., Lefevre, R.N., James, H.H., Matthews, J.D., Nicholls, W., Pattison, H., Sheflin, M.J.,** "Pavement Management Systems — Guidelines for Municipalities," Report PAV-83-05, Ministry of Transportation and Communications, Ontario, Canada, 1983.

[5] **Chong, G.J.,** "A Road Rideability Rating Experiment," Report IR-19, Ministry of Transportation and Communications, Ontario, Canada, 1968.

[6] **Chong, G.J., Jewer, F.W., Macey, K.,** *Pavement Maintenance Guidelines — Distresses, Maintenance Alternatives and Performance Standards*, Report SP-001, Ministry of Transportation and Communications, Ontario, Canada, 1980.

[7] **Chong, G.J., Phang, W.A., Jewer, F.W.,** "Choosing Cost-Effective Maintenance," Report PAV-80-03, Ministry of Transportation and Communications, Ontario, Canada, 1980. Presented at the Roads and Transportation Association of Canada, Toronto, 1980. Also presented at the Annual Meeting of the Transportation Research Board, Washington, D.C., 1981.

[8] **Blum, W.E., Phang, W.A.,** "Preventive Pavement Maintenance Concepts," Report PAV-80-04, Ministry of Transportation and Communications, Ontario, Canada, 1981.

[9] **Hajek, J.J., Phang, W.A., Wrong, G.A., Prakash, A., Stott, G.M.,** "Pavement Condition Index (PCI) for Flexible Pavements," Report PAV-86-02, Ministry of Transportation and Communications, Ontario, Canada, 1986.

Appendix A
Guide for Completing the "Flexible Pavement Condition Evaluation Form"

Pavement Identification

Pavement sections under evaluation must be identified by completing the following (refer also to Figure A-1):

1. Road Number or Street Name — Name of Road or Street under evaluation.
2. Location — Beginning of pavement section under evaluation referenced by permanent landmark X to end of section under evaluation referenced by permanent landmark Y.
3. Section Length — Length of section under evaluation in metres or kilometres.
4. Survey Date — Date of evaluation.
5. Traffic Direction — The direction traffic moves on the section under evaluation. If the section is to be for all lanes (e.g. a two-lane road or street), use the code B, meaning both directions. On multi-lane roads or streets (divided or undivided), record the appropriate traffic direction code.
6. Class — Record the appropriate code as noted on the form for the class of road or street (e.g., major arterial road, connecting link, or residential).
7. Contract Number --- The last construction or major rehabilitation contract number.
8. Work Project Number — If future work project is under planning process and a work project number is available.

Pavement Evaluation

1/ Riding Condition Rating:

Riding condition rating is an indicator of how well the pavement serves the travelling public and is measured subjectively in terms of pavement surface roughness as experienced by the rater. It is a measure related to road user comfort, cost and safety, and is therefore referred to as the functional pavement performance. [9]

Riding condition rating of the evaluation section is made by the rater driving over the pavement at the posted speed and the appropriate rating is recorded in the proper space in the evaluation form (Figure A-1).

2/ Pavement Surface Distress Manifestations

Pavement evaluation is also made in terms of pavement distresses which may cause accelerated loss of pavement serviceability and/or distresses which may trigger pavement maintenance actions. It is a measure related to the structural adequacy of the pavement and the cost of maintaining and preserving the capital investment of the road structure, and is therefore referred to as the structural pavement performance [9].

Pavement surface distress manifestations are evaluated by the rater either walking and/or driving slowly over the evaluation section and checking off all the pavement distress manifestations in their appropriate spaces (Figure A-1).

The rater must evaluate all visible distress manifestations of their severity and extent of occurrence according to the established parameters.

The pavement distresses are listed under three subgroups:

a/ **Pavement Surface Defects**
Ravelling
Flushing
Potholes
Pavement Edge Break
Manholes and Catchbasins
b/ **Pavement Surface Deformations**
Rippling and Shoving
Wheel Track Rutting
Distortion
Utility Trenches
c/ **Pavement Cracking**
Longitudinal
Transverse
Pavement Edge
Map
Alligator

Pavement Shoulder Evaluation

Although pavement shoulder condition has no influence on the Pavement Condition Rating, shoulder distresses can and do affect pavement serviceability.

Shoulder distress manifestations, however, are evaluated only for paved or treated shoulder for practical reasons.

Paved or treated shoulder distresses are evaluated by the rater under the same manner as evaluating pavement surface and the distress is checked off in its appropriate space on the form (Figure A-1).

The distress is evaluated according to its severity and extent of occurrence (see Chapter 6) and identified as on "Right" or "Left" shoulder by the direction of the road or street.

On a road running from south to north, the shoulder on the east side is always "Right". On a road running from east to west, the shoulder on the north side is always "Right".

The shoulder distresses are listed as:

a/ Pavement Edge and Paved Shoulder or Curb/Gutter Separation
b/ Cracking
c/ Breaking and Potholes
d/ Distortion

Maintenance Treatment Evaluation

Maintenance treatment should be reported by its type and the extent of occurrence by checking off the appropriate spaces (Figure A-1). The maintenance treatment alternatives listed on the form are fully described in Chapter 7.

The extent and type of maintenance treatment is generally indicative of how well the pavement performs both functionally and structurally. Therefore, it is important that this information is made available through proper recording.

Pavement Condition Rating (PCR)

Pavement Condition Rating is a subjectively derived rating number of level of serviceability based on evaluation of the pavement riding quality and pavement surface distresses such as distortion, cracking, alligatoring, and so on. It is an assessment of the overall pavement performance both functionally and structurally as related to actual observable pavement characteristics, namely, roughness and various distress manifestations.

The Pavement Condition Rating is assigned according to the guidelines provided in Table A-1. The guide also suggests the type and timing of maintenance activities or rehabilitation matching the Pavement Condition Rating.

FLEXIBLE PAVEMENT CONDITION EVALUATION FORM (MUNICIPALITIES)

Road No. (Street) ____________ Location from ____________ To ____________

Section Length ________ (Km) (m) Survey Date ________ Traffic Direction ☐ B: Both Directions, N: North Bound S: South Bound, E: East Bound, W: West Bound

Contract No. ____________ Work Project No. ________ Class ☐ F: Freeway, C: Connecting Link, A: Major Artierial M: Minor Artierial, R: Residential

Pavement Condition Rating (PCR) ________ Riding Condition Rating (RCR) ________ Evaluated by ____________

Riding Condition Rating (At Posted Speed)

10 – 8	8 – 6	6 – 4	4 – 2	2 – 0
Excellent	Good	Fair	Poor	Very Poor
Smooth and Pleasant	Comfort-able	Uncomfort-able	Very Rough and Bumpy	Dangerous at Posted Speed

Pavement Distress Manifestation			Severity of Distress			Density of Distress % Extent of Occurrence		
			Slight	Moderate	Severe	Intermittent	Frequent	Extensive
						<20	20-50	>50
			1	2	3	1	2	3
Surface Defects	Ravelling	1						
	Flushing	2						
	Potholes	3						
	Pavement Edge Breaks	4						
	Manholes & Catchbasins	5						
Surface Deformation	Rippling and Shoving	6						
	Wheel Track Rutting	7						
	Distortion	8						
	Utility Trenches	9						
Cracking	Longitudinal	10						
	Transverse	11						
	Pavement Edge	12						
	Map	13						
	Alligator	14						

Distress Comments (Items not covered above) ____________

____

Recommendation by Evaluator

____

____

Shoulder Distress Manifestation			Severity of Distress						Density of Distress % Extent of Occurrence					
			Right			Left			Right			Left		
Dominant TYPE	√ one	Distress	Sli	Mod	Sev	Sli	Mod	Sev	<2o	2o-5o	>5o	<2o	2o-5o	>5o
			1	2	3	1	2	3	1	2	3	1	2	3
Paved Full		Pavement Edge												
		Paved Shoulder Separation												
Paved Partial		Cracking												
Surface Treated		Breakup and Potholes												
		Distortion												
Primed		Pavement Edge Curb Separation												

Maintenance Treatment							
Pavement	Extent of Occurrence %			Shoulder	Extent of Occurrence %		
	<20	20-50	>50		<20	20-50	>50
	1	2	3		1	2	3
Manual Patching				Manual Patching			
Machine Patching				Manual Spray Patching			
Manual Spray Patching				Manual Chip Seal			
Manual Chip Seal				Crack Rout and Seal			
Machine Chip Seal							
Fog Seal							
Surface Treatment							
Manual Burn & Seal							
Crack Rout and Seal							

Figure A-1 Pavement Condition Rating Form

Table A–1

A Guide for the Estimation of Pavement Condition Rating and Suggested Maintenance or Rehabilitation for Municipal Roads and Streets.

Pavement is in excellent condition with very smooth ride, just a few bumps or depressions from slight surface deformation distresses. No surface defects or cracking distresses. Ride is very good (8 - 10).	80 - 100	No Maintenance
Pavement is in good condition with smooth ride. Just a few bumps or depressions from slight to moderate surface deformation distresses. Slight to moderate intermittent surface defects and/or cracking distresses. Ride is good (6 - 8).	60 - 80	Normal Maintenance Potential Candidate for Preventive Maintenance Strategy.
Pavement is in fair condition with acceptable ride. Intermittent to frequent bumps or depressions from surface deformation distresses. Moderate intermittent to frequent surface defects and or cracking distresses. Localized slight alligator cracking may be present. Ride is fair (4 - 6).	40 - 60	Corrective Maintenance to hold serviceability level. Candidate for major corrective maintenance as holding strategy. Candidate for rehabilitation program in 5 years.
Pavement is in poor condition with barely acceptable ride from frequent bumps or depressions because of moderate deformation distresses. Moderate to severe frequent surface defects and/or cracking distresses. Localized slight to moderate alligator cracking may be present. Ride is poor (2 - 4).	20 - 40	Corrective Maintenance to retard rapid deterioration of serviceability level. Candidate for rehabilitation program in 3-5 years.
Pavement is in very poor condition with uncomfortable ride. Frequent to extensive bumps or depressions from moderate to severe frequent to extensive surface defects and/or cracking distresses. Frequent slight to moderate alligator cracking may be present. Ride is very poor (0 - 2).	0 - 20	Corrective Maintenance when necessary to maintain safety and minimal serviceability level. Rehabilitation now or within 3 years.